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Notes on some Copepoda from the Faroe Channel.
By THOMAS SCOTT, LL.D., F.L.S.

[Read 18th December, 1902.]

(PLATES **1–3**.)

It sometimes happens, during marine investigations, that pieces of water-logged and partly-decayed wood are brought up in the dredge or trawl-net. These pieces of wood, if carefully examined, will not infrequently be found to harbour rare, and sometimes undescribed, species of Entomostraca. In such pieces of wood dredged in the Clyde, the Firth of Forth, and elsewhere I have obtained the somewhat rare ostracod *Cytheropteron humile*, Brady & Norman, in considerable numbers; and my son, Mr. Andrew Scott, has found the same ostracod in similar pieces of wood from Barrow Channel, Lancashire [*]. This ostracod was described in 1889 [†], and at that time the Clyde near Greenock, and Vigo Bay, Spain, were the only two places where it was known to have been obtained. Moreover, it is in such pieces of wood, and often associated with the ostracod named, that I usually find the curious copepod *Laophonte simulans*, T. Scott [‡]. The Copepoda recorded in the following notes were, like the two species just referred to, obtained from

[*] Trans. Liverpool Biol. Soc. vol. xv. (1901) p. 348.
[†] "Mon. Marine and F.-W. Ostrac.," by Prof. G. S. Brady and Rev. A. M. Norman (Trans. Roy. Dublin Soc. vol. iv. s. II. p. 219, pl. 20. figs. 4–7).
[‡] 15th Ann. Rep. Fishery Board for Scotland, part iii. (1897) p. 151.

a piece of wood dredged from about 87 fathoms in the Faroe Channel; the wood was perforated to a considerable extent by the boring mollusk, *Xylophaga dorsalis*, Turton. Seven species of Copepoda, each representing a separate genus, and all belonging to the Harpacticidæ, were obtained in this piece of wood; three of the species appear to be undescribed, but the others are all more or less widely distributed.

The drawings which illustrate these notes were made a few years ago by my son, Mr. Andrew Scott, but shortly afterwards were mislaid and have only recently been recovered.

COPEPODA.

HARPACTICIDÆ.

ZOSIME, *Boeck*, 1872 *.

ZOSIME TYPICA, *Boeck*.

This species, which is somewhat widely distributed, was represented by very few specimens.

PSEUDOTACHIDIUS, *T. Scott*, 1898 †.

The genus *Pseudotachidius* was instituted in 1898 for an interesting copepod discovered in the deep water at the mouth of Loch Fyne, and as there was but one species known at the time, the generic description was included in that of the species; but as another copepod has been found belonging apparently to the same generic type, it will be better now to give a separate definition of the genus.

Definition of the Genus Pseudotachidius, *T. Scott.*

Cephalothorax moderately broad, somewhat depressed; abdomen moderately narrow, more or less distinct from the cephalothorax. Antennules short, five- or six-jointed. Antennæ with secondary branches well developed and composed of three joints. Mandibles nearly as in *Tachidius*, Lilljeborg, and with a moderately developed two-branched palp. Other mouth-organs also similar to those of *Tachidius*. Both branches of the first four pairs of thoracic feet three-jointed, inner branches of first pair

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* Mon. British Copepoda, Brady, vol. ii. p. 14 (1880).
† 16th Ann. Rep. Fishery Board for Scotland, part iii. p. 267 (1898).

non-prehensile. Fifth pair small, composed of two joints; basal joints usually not greatly developed; secondary joints usually small, but quite distinct.

Remarks.—This genus appears to be more nearly related to *Tachidius* than to any of the other allied genera, but it differs distinctly in the structure of the secondary branches of the antennæ and of the fifth pair of thoracic feet. Moreover, though it might be included in the subfamily *Tachidiinæ*, Boeck, with as much propriety as the genus *Robertsonia*, G. S. Brady, which has the fifth pair also composed of two joints, I prefer meanwhile, till we know more about the structure of the male, to regard *Pseudotachidius* simply as a member of the Harpacticidæ.

PSEUDOTACHIDIUS SIMILIS, sp. n. (Pl. 1. figs. 1–8.)

Description of the female.—Length about ·8 mm. ($\frac{1}{30}$ of an inch). The body is moderately robust and, when seen from above, is subcylindrical, but tapering slightly towards the posterior end; the rostrum is moderately broad and rounded (fig. 1).

The antennules are short and stout, and composed of five joints, but the fourth joint is very small (fig. 2); they are each provided with numerous plumose setæ, and a short and stout sensory filament springs from the distal end of the third joint, as shown in the figure.

The antennæ (fig. 3) are somewhat similar in structure to those of *Pseudotachidius coronatus*, T. Scott; but there is some difference of the armature, especially of the primary branches, the terminal spines of which are stouter than in that species.

The mandibles (fig. 4) are moderately stout, the biting-edge in each is subtruncate and armed with several small teeth. The basal joint of the palp is somewhat dilated and provided with two small setiferous branches; the upper branch is composed of one and the lower of two joints, as shown in the drawing. The mandibles and other mouth-organs resemble the organs corresponding to them in *Pseudotachidius coronatus.*

The first four pairs of thoracic feet have both branches three-jointed. In the first pair the second basal joints are each provided with a stout setiferous spine on both its outer and inner aspects; both branches of this pair, as well as the marginal spines of the outer branches, are also setiferous (fig. 6). The inner branches are scarcely so long as the outer ones, whereas

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in the first pair in *Pseudotachidius coronatus* the inner are longer than the outer branches.

The second, third, and fourth pairs are somewhat similar to the same appendages in *Pseudotachidius coronatus*; figure 7 represents the fourth pair, and the second and third do not appear to differ very greatly from this.

The fifth pair also resembles the fifth pair of the species referred to, but the armature is somewhat different, and there appears to be no distinct secondary joint (fig. 8).

The furcal joints are very short.

No males were observed.

Remarks.—The species just described may be distinguished from *Pseudotachidius coronatus*, T. Scott, the only other member of the genus, by the difference in the structure of the antennules, by the inner branches of the first pair of thoracic feet being not longer than the outer branches, and by the difference in the armature of the fifth pair.

This was one of the rarest of the copepods obtained from the piece of wood already referred to, and only a single specimen was observed.

Cervinia (*Norman, MS.*), *Brady*, 1878 *.

Cervinia Bradyi (*Norman, MS.*), *Brady, loc. cit.*; *Giesbrecht*, *Mitth. a. d. Zool. Stat. zu Neapel*, vol. xiv. pt. 1, p. 58 (1900).

We owe the discovery of this interesting species to the Rev. A. M. Norman, who captured three specimens at Oban in July 1877, while dredging there †. *Cervinia Bradyi* appears to be a scarce species, for although, subsequent to its discovery at Oban, it has been found in a few other places in Britain, it has never occurred but in single, or at most few, specimens at one time. This, like the last, was rare in the material washed from the perforated wood.

Laophonte, *Philippi*, 1840 ‡.

Laophonte farüensis, sp. n.   (Pl. 1. figs. 9–14; Pl. 2. figs. 1–8.)

Description of the female.—The length of the specimen repre- sented by the drawing is ·77 mm. (about $\frac{1}{32}$ of an inch); it

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* Mon. British Copepoda, G. S. Brady, vol. i. p. 85 (1878).

† *Ibid.* p. 86, pl. xxiv A. figs. 3–13.

‡ *Ibid.* vol. ii. p. 78 (1880).

somewhat resembles *Laophonte curticauda*, Boeck, in general appearance, except that the second segment of the abdomen is rather wider than the segment which precedes it, and also than those which follow (Pl. 1. fig. 9).

The rostrum, which is moderately broad, is bluntly rounded at the apex, and scarcely reaches to the end of the first joint of the antennules.

The antennules are about as long as the cephalothoracic segment, seven-jointed, and moderately setiferous; the first three joints are subequal, and together are equal to fully one and a half times the entire length of the remaining four joints; the fourth and fifth joints are rather shorter than the sixth and seventh, and the fourth is furnished with a sensory filament (Pl. 2. fig. 1).

The penultimate joints of the antennæ are each provided with a small uniarticulate secondary appendage which bears a few plumose setæ (Pl. 2. fig. 2).

The mandibles (Pl. 2. fig. 3) are of moderate size, but the palp is very small and uniarticulate.

The other mouth-organs resemble those of *Laophonte curticauda*, but the second maxillipeds (Pl. 1. fig. 11) are proportionally rather stouter.

The first pair of thoracic feet are somewhat similar to those of the same species, but the joints of the outer branches are subequal in length (Pl. 1. fig. 12). The second, third, and fourth pairs have the inner branches short and two-jointed, the first joints being small; the outer branches are moderately elongated. The drawing (Pl. 2. fig. 4) represents the fourth pair.

In the fifth pair, which are foliaceous, the basal joints have a somewhat triangular outline, but the inner portion is produced so as to reach to near the middle of the secondary joints; the inner margin of the produced part is provided with apparently three moderately stout setæ in addition to a small seta at the apex. The secondary joints are subcylindrical; they are fully twice as long as broad, and are each furnished with about five small setæ on the distal half of the outer margin and apex, as shown in the drawing (Pl. 2. fig. 5).

The furcal joints are about as long as the last abdominal segment.

The *male* appears to differ very little from the female, except in the following particulars:—The antennules, as shown in the

drawing (Pl. 2. fig. 6), are modified for grasping ; the first two joints are moderately stout, the third is very small, while the fourth is considerably dilated ; the remaining joints, which are small and hinged to the fourth, form together a kind of movable claw. The inner branches of the third pair of thoracic feet appear to be three-jointed (Pl. 2. fig. 7) ; the end joint, which is small and somewhat indistinct, is furnished with four terminal plumose setæ of variable lengths, while the distal end of the second joint is produced into a moderately stout hook-like process ; the outer branches are not only proportionally more robust, but are also provided with rather stouter spines than the same pair in the female.

The outer branches of the fourth pair are also more robust than the outer branches of the same pair in the female ; the inner branches scarcely reach to the end of the first joint of the outer branches ; they are composed of two joints, but the end joint is about twice the length of the other, and bears a long spine-like seta on its outer distal angle, and four moderately long plumose setæ—two at the apex and two on the inner margin, as shown in the drawing (Pl. 1. fig. 13).

The fifth pair (Pl. 1. fig. 14) are very small ; the basal joint is not produced interiorly, and is provided with a single plumose seta ; the secondary joint is subcylindrical, but somewhat wider at the distal end, and provided with about four apical setæ.

This species, like most of the others, was a moderately rare one in the material washed from the perforated wood ; it seems to differ from any *Laophonte* known to me.

Cletodes, *Brady*, 1872 *.

Cletodes armata, sp. n.   (Pl. 3. figs. 4–14.)

Description of the female represented by the drawing (fig. 4) :—
Length about 1·5 (fully $\frac{1}{15}$ of an inch) ; seen from above the body is elongated and subcylindrical ; the cephalic segment is somewhat longer than the next two taken together, the second to the fifth segments are subequal in length. The first two segments of the abdomen appear to be coalescent, but the others are distinct. The thoracic and abdominal segments are all fringed with a few short and moderately stout spines, as shown in the drawing. The furcal joints are elongated and slender, being

* Mon. British Copepoda, vol. ii. p. 89 (1880).

nearly as long as the abdomen. The forehead is somewhat angular and armed with a minute spine.

The antennules (Pl. **3.** fig. 5) are moderately long and slender and composed of five joints ; the first three joints are short, but the other two are elongated and narrow, and a moderately long sensory filament springs from the end of the penultimate joint ; the formula shows approximately the proportional lengths of the various joints :—

Number of the joints	1	2	3	4	5
Proportional lengths of the joints	5	9	11	20	14

The antennæ, which are slender and of moderate length, are sparingly setiferous ; the secondary branches appear to be entirely obsolete (Pl. **3.** fig. 6).

The mandibles (Pl. **3.** fig. 7) are stout, and have the biting-edge obliquely truncate and armed with several teeth ; the mandible-palp is small, and composed of a single uniarticulate branch.

The first pair of maxillipeds are each moderately stout and armed with a stout terminal claw, bearing a few small setæ, and also with two bisetose marginal papillæ (Pl. **3.** fig. 8).

The second maxillipeds are also moderately stout, and the terminal claw is curved and somewhat slender and elongated (Pl. **3.** fig. 9).

The thoracic feet are all moderately slender. In the first four pairs the outer branches are all composed of three and the inner of two joints. The first pair has the inner branches very short, they scarcely reach to the end of the second joint of the outer branches, and their first joint is almost obsolete, the second joint bears two small spiniform apical setæ ; the outer branches are moderately elongate, and armed with long slender marginal and terminal spines, as shown in the drawing (Pl. **3.** fig. 10). Both branches of the next three pairs are slender, the outer branches being more slender than those of the first pair ; the first joints of the inner branches are very short, but the second is elongate, and the terminal setæ of both the inner and outer branches are considerably longer than the branches from which they spring ; figure 11 represents the fourth pair.

The fifth pair (Pl. **3.** fig. 12) are small ; the inner portion of the basal joint is produced into a moderately long and narrow appendage, which is furnished with four spiniform setæ on the apex and distal part of the inner margin ; the outer portion of

the basal joint extends into an elongate and slender process bearing a single seta at its extremity. The secondary joints are very narrow and reach to about the end of the inner produced part of the basal joints; they are each provided with two apical setæ—one long and one very short—and a small seta near the distal end of the outer margin (Pl. 3. fig. 12).

The *male* differs little from the female, except in the following particulars :—The antennules are modified as shown in the drawing (Pl. 3. fig. 13). The third pair of thoracic feet are furnished with a sigmoid appendage, which is moderately stout at the base, but tapers towards the extremity (fig. 14). The fifth pair of feet also differ slightly from those of the female.

The *Cletodes* just defined is distinctly different from any described species with which I am familiar; its slender form, elongated caudal furca, and the peculiar structure of the antennules distinguish it almost at a glance from allied species. Only a few specimens were obtained.

DACTYLOPUS, *Claus*, 1863 *.

DACTYLOPUS STRÖMII (*Baird*), var. FARÖENSIS, var. n.   (Pl. 2. figs. 9–14; Pl. 3. figs. 1–3.)

1837. *Cyclops Strömii*, Baird, Mag. Zool. & Bot. vol. i. p. 330, t. 9. figs. 23–25.

1863. *Dactylopus Strömii*, Claus, Die frei-lebenden Copepoden, p. 126, t. 16. figs. 1–13.

Description of the female.—Body moderately stout; rostrum short (Pl. 2. fig. 9). Length from the extremity of the rostrum to the end of the caudal furca about 1 mm.

Antennules eight-jointed, somewhat similar in structure to those of *Dactylopus Strömii*; but when compared with the description and figures given by Claus there appears to be a slight difference in the proportional lengths of the last four joints. Claus states that the fifth and seventh joints are short, and his figure shows them as being subequal; whereas in our specimen the fifth joint is short, the sixth and seventh subequal and longer than the fifth, while the last, which is longer than either of the three preceding joints, is about equal in length to

* Mon. British Copepoda, Brady, vol. ii. p. 105 (1880).

the fourth (Pl. 2. fig. 10). The proportional lengths of the various joints are shown by the formula :—

Number of the joints	1	2	3	4	5	6	7	8
Proportional lengths of the joints.	16	14	10	13	5	7	8	13

The antennæ (second antennæ) are somewhat similar to those of *Dactylopus Strömii.*

The mandibles (Pl. 2. fig. 11) are also similar to those of the same species.

The second maxillipeds (second foot-jaws) are moderately stout; the first and second joints are each provided with two small setæ, as shown in the drawing (Pl. 2. fig. 12). The terminal claw, which is nearly as long as the second joint, is only slightly curved, and furnished with a small lateral seta.

The first four pairs of thoracic feet are almost similar to those of *Dactylopus Strömii* (Pl. 2. fig. 13).

The fifth pair (Pl. 2. fig. 14) have a general resemblance to the same pair of feet in *Dactylopus Strömii*, but the armature of the basal joint and the form as well as the armature of secondary joint are different; the basal joint is furnished with about five terminal setæ, the two innermost of which are short and of nearly equal length, the next two are also subequal, but they are about twice the length of the others—all these four setæ are moderately stout; the fifth, which is close to the fourth, is comparatively small and slender. The secondary joint is broadly ovate and is provided with six setæ round the distal end; the innermost and the three outermost of these setæ are moderately stout and plumose, while the remaining two are slender and elongate.

The furcal joints are very short.

The *male* differs from the female in several particulars, the following of which appear to be the more obvious :—The antennules (anterior antennæ) are modified for grasping. The first joint of the inner branches of the first thoracic feet (Pl. 3. fig. 1) is shorter and proportionally much stouter than that of the inner branches of the first pair in the female. The end joint of the inner branches of the second pair of feet is prolonged into a stout and spiniform process, which extends beyond the end of the outer branches, and which bears one or two setæ, as well as an elongated slender filament (Pl. 3. fig. 2). The fifth pair

are nearly similar in form and armature to those of the male of *Dactylopus Strömii* (Pl. **3**. fig. 3).

Perhaps the *Dactylopus* just described ought to be regarded as a distinct species, because of the differences which characterize both sexes when compared with its nearest of kin, *Dactylopus Strömii* (Baird), but meanwhile I prefer to consider it merely as a variety of that species. A number of males and females were found.

IDYA, *Philippi*, 1843 *.

IDYA FURCATA (*Baird*).

This species was also washed from the piece of perforated wood dredged at Faroe, and is the last I have at present to record. *Idya furcata* appears to have an extensive distribution; it is a moderately common form around the British Islands, and it sometimes occurs in large numbers in the material washed from the filters at the Sea-fish Hatchery of the Fishery Board for Scotland; it has been obtained in gatherings of Copepoda from Franz-Josef Land and other places within the Arctic seas, and also in material collected by the aid of a ship's pump in the vicinity of Suez. Its occurrence near Faroe at a depth of over 80 fathoms is an indication that the species is not limited to littoral or shallow-water conditions.

EXPLANATION OF THE PLATES.

PLATE **1**.

Pseudotachidius similis, sp. n.

Fig. 1. Female, dorsal view.   × 64.
    2. One of the antennules.   × 190.
    3. One of the antennæ.   × 190.
    4. One of the mandibles.   × 300.
    5. One of the maxillæ.   × 253.
    6. One of first pair of thoracic feet.   × 253.
    7. One of fourth pair.   × 253.
    8. Foot of fifth pair.   × 253.

Laophonte faröensis, sp. n.

Fig.   9. Female, dorsal view.   × 52.
    10. First maxilliped.   × 500.
    11. Second maxilliped.   × 300.

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* Mon. British Copepoda, Brady, vol. ii, p. 171 (1880).

Scott.

Linn Soc. Journ. Zool. Vol.XXIX, Pl.1.
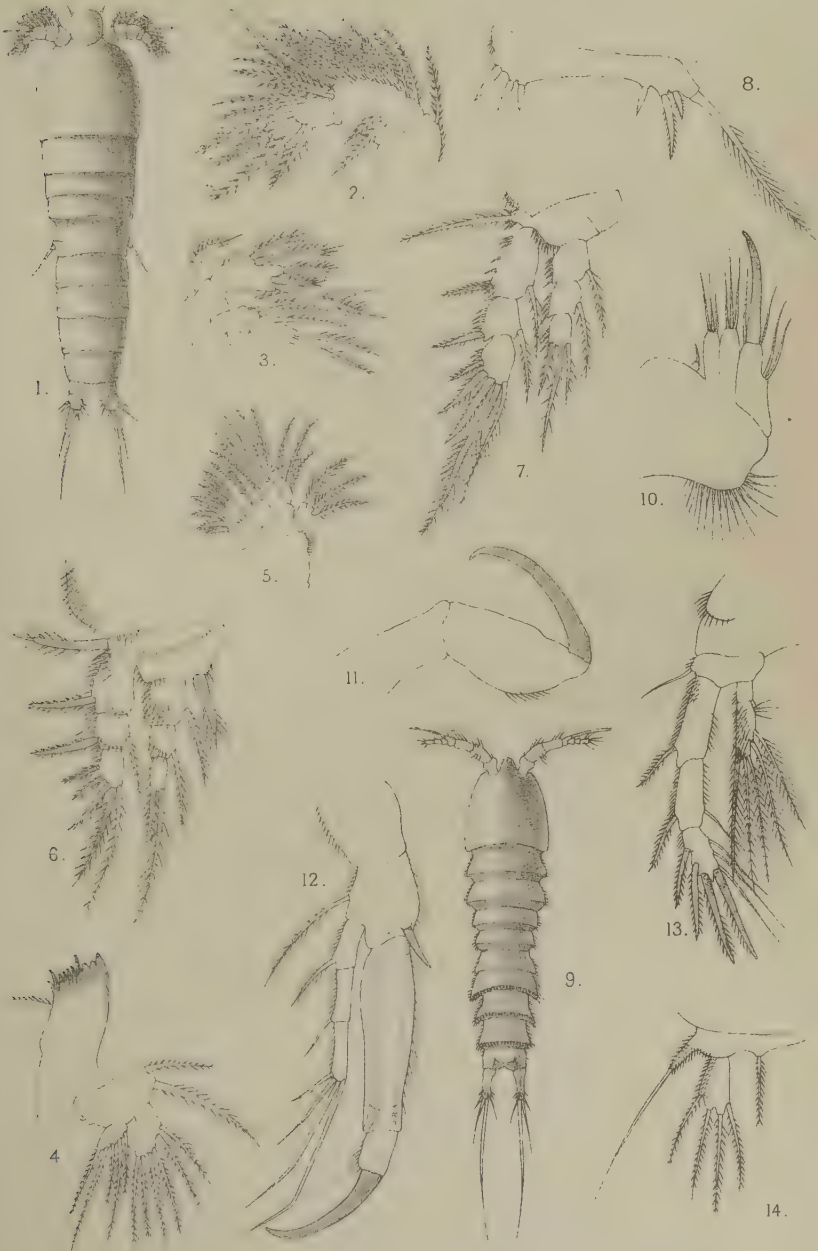
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1-8. PSEUDOTACHIDIUS SIMILIS   9-14, LAOPHONTE FAROENSIS.

Scott.

Linn. Soc. Journ. Zool. Vol. XXIX, Pl. 2.

1-8, LAOPHONTE FARÖENSIS   9-14 DACTYLOPUS STRÖMII, var.

1-3, DACTYLOPUS STRÖMII, var.　　4-14, CLETODES ARMATA.

Fig. 12. Foot of first pair of thoracic feet.   × 253.
    13. Foot of fourth pair (male).   × 200.
    14. Foot of fifth pair (male).   × 300.

PLATE 2.

Laophonte faröensis, sp. n.

Fig. 1. One of the female antennules.   × 300.
    2. One of the antennæ.   × 253.
    3. One of the mandibles.   × 253.
    4. Foot of fourth pair of thoracic feet.   × 168.
    5. Foot of fifth pair.   × 300.
    6. One of the male antennules.   × 300.
    7. Foot of third pair of thoracic feet (male).   × 200.
    8. Appendage to first abdominal segment.   × 380.

Dactylopus Strömii, var. *faröensis*, var. n.

Fig. 9. Female, lateral view.   × 53.
    10. One of the antennules.   × 168.
    11. One of the mandibles.   × 252.
    12. Second maxilliped.   × 300.
    13. Foot of first pair of thoracic feet.   × 200.
    14. Foot of fifth pair.   × 168.

PLATE 3.

Dactylopus Strömsii, var. *faröensis*, var. n.

Fig. 1. Foot of first pair of thoracic feet (male).   × 252.
    2. Foot of second pair (male).   × 252.
    3. Foot of fifth pair (male).   × 252.

Cletodes armata, sp. n.

Fig. 4. Female, dorsal view.   × 40.
    5. Antennule and portion of cephalothoracic segment.   × 152.
    6. One of the antennæ.   × 190.
    7. One of the mandibles.   × 252.
    8. One of the first maxillipeds.   × 300.
    9. One of the second maxillipeds.   × 380.
    10. Foot of first pair of thoracic feet.   × 253.
    11. Foot of fourth pair.   × 126.
    12. Foot of fifth pair.   × 190.
    13. One of the male antennules.   × 152.
    14. Foot of third pair of thoracic feet.   × 190.

The Deep-Sea Isopod *Anuropus branchiatus*, Bedd., and some
    Remarks on *Bathynomus giganteus*, A. M.-Edw. By Dr. H.
    J. HANSEN (Copenhagen), F.M.L.S.

[Read 18th December, 1902.]

(PLATE 4.)

I. ANUROPUS BRANCHIATUS, *Beddard*.

A RICH collection of Isopoda was secured by the ' Challenger '
and described by F. E. Beddard. In Part II. of his Report (in
vol. xvii. 1886) the author asserts with good reason respecting
the form *Anuropus branchiatus*, Bedd.: " This genus is quite the
most remarkable that was obtained during the voyage ; it is
represented only by a single individual from deep water (1070
fathoms) in the Western Pacific, off New Guinea." No expedition
has met with the animal again. Beddard refers *Anuropus* to
the family Cymothoidæ, without further remarks on its position
within this very extensive group ; he devotes nearly four pages
(pp. 152–156) to the description and five figures on pl. vii. He
correctly points out that the uropoda have been developed as
supplementary respiratory organs, in all respects similar to the
pleopoda, and that no trace of eyes is to be found ; furthermore,
he describes the reduced antennulæ, the antennæ, legs, &c. But
his description of the mouth-parts is defective, and the figure
(fig. 4) representing these organs is insufficient, wherefore the
genus has been to a certain extent a puzzle to later systematic
writers.

In 1890 I published a paper : " Cirolanidæ et familiæ non-
nullæ propinquæ Musei Hauniensis " (Kgl. Danske Vidensk.
Selsk. Skrifter. 6 Række, naturv. og math. Afd. B. v. iii. (1890)
3, pp. 239-426, tab. 1–10), in which I attempted to bring about
some order in the extensive group, which may be named the
Cymothoidæ after one of its types. I referred all the animals
in question to six families : Cirolanidæ, Corallanidæ, Alcironidæ,
Barybrotidæ, Ægidæ, and Cymothoidæ, and these have been
adopted by all authors who have since written on the group.
In 1895 I attempted, in " Isopoden, Cumaceen und Stomato-
poden der Plankton-Expedition " (Ergebn. d. Plankt.-Exped. d.
Humboldt-Stiftung, B. II. G. *c*), to produce an arrangement of
the families of the order Isopoda. In order to procure a tolerable

equivalence between the families, I established the group Cymo-
thoidæ, sens. lat., as a family of the same value as the families
Anthuridæ, Bopyridæ (Epicarida), &c.   The six above-named
families were now considered as subfamilies, *Cirolaninæ, Coralla-
ninæ*, &c., of the family Cymothoidæ.

In the above-named paper of 1890 I have allowed two-thirds
of a page (pp. 254–255) to an extract and critical review of
Beddard's description and drawings of *Anuropus branchiatus*.
I will here only translate the following lines:—"As a kind of
résumé, I can only say that *Anuropus* either, and probably, must
belong to my family Cirolanidæ, or that it, if the structure of
the mouth should present unknown and deviating features of
significance, must be established as the type of a new family."
When the arrangement in my Plankton paper is followed, the
result will therefore be that *Anuropus* must either be referred to
the subfamily *Cirolaninæ*, or established as the type of a new sub-
family, *Anuropinæ*, the seventh one of the family Cymothoidæ.

In his very interesting and useful book, 'A History of Crus-
tacea—Recent Malacostraca,' 1893 (Internat. Scient. Series),
the Rev. T. R. R. Stebbing adopts my arrangement of the group;
but on *Anuropus* he writes (p. 345) that it "may have greater
claims to be the type of a distinct family, Anuropidæ, since, in
addition to the conversion of the uropods into branchial pleopods,
and the absence of eyes, the first antennæ have only two joints,
and the very short ' palp ' of the maxillipeds consists of a single
joint." As to this view, I refer to the following pages. I am
not aware that any other author has contributed to the discussion
of the systematic position of this aberrant genus.

During a stay in London in July and August 1902, I took the
good opportunity to examine the type-specimen of *Anuropus*
preserved in the British Museum (Natural History). I am much
indebted to Professor F. Jeffrey Bell for the permission to study
that interesting animal, and I beg him to accept my sincere
thanks. The specimen proved to be rather badly preserved: of
the thoracic legs only two were complete (or nearly so); the
antennæ and the mandibular palpi were incomplete; of the mouth-
parts the three posterior appendages on the left side had been
removed, and could not be found in the collection.   I did not
remove by dissection any of the remaining mouth-parts; the shape
and structure of the mandibles could be studied without much
difficulty.   In order to see the maxillula and the maxilla I have

bent the maxilliped (and the maxilla) backwards, but the figures
in question (Pl. 4. figs. 4 & 5) have been drawn without camera.
My figures of the mouth-parts show all the details necessary for the
purpose : only the basal part of the maxillula has been omitted ;
it could not be examined without undertaking a dissection, but
fortunately it is of slight or no importance in this connection.
I must add that I do not deem it necessary to redescribe every
detail, or to draw a complete set of new figures. As to the
thorax and abdomen, I refer the reader to the description and
figures in Beddard's work, confining myself essentially to some
remarks, additional and critical, and figures of two legs. For
comparison with the *Cirolaninæ* (and *Alcironinæ*), the student is
constantly referred to my above-named paper published in 1890.

Head.—It is proportionately rather short and narrow, but
deep : in Pl. 4. fig. 1 it is shown obliquely from in front and some-
what from below; in fig. 2 from below and somewhat from behind.
On the front side it presents a rather deep and exceedingly high
transverse groove (a), which tapers somewhat towards the middle
line, where it is interrupted in the upper half by a narrow
vertical keel, and in the lower half by the frontal plate. In the
groove the antennulæ (c) and the antennæ (d) are situated. The
groove is limited below by a thick transverse wall (e), which at
the middle turns upwards, constituting the upper part of the
frontal plate ; the lower part of this plate is not marked off
laterally from the wall by any suture or impression, while in the
Cirolaninæ and *Alcironinæ* the plate is always sharply defined
on all sides. The clypeus (f) is situated below the wall and
marked off from it by a deep, somewhat sinuate transverse
impression, without any real suture.

Antennulæ (Pl. 4. fig. 1, c).—These are exceedingly thick and
moderately short, reaching slightly beyond the lateral margin of
the head, and each consisting only of two joints. The basal joint
is shorter than thick, and I am inclined to suppose that it is
homologous with the two proximal joints of the peduncle in many
Cirolaninæ; the distal joint would then correspond with the third
joint of the peduncle and the flagellum together—but I cannot
prove the correctness of this supposition.

Antennæ (Pl. 4. fig. 1, d).—These consist, according to Beddard,
of a four-jointed peduncle and a nine-jointed flagellum. In the
specimen the peduncle has been preserved ; it is considerably

longer than the antennulæ, slender, the two proximal joints rather short, the third a little longer and the fourth a little shorter than the two proximal ones together.

Labrum (*g* in Pl. 4. figs. 1 & 2).—It is somewhat smaller than in *Eurydice* and other *Cirolaninæ*, but not very different in shape ; it is about twice as broad as long, with the basal margin slightly concave, the distal rather flatly convex.

Mandibles (*h* in Pl. 4. figs. 1 & 2).—These are robust in their whole length, a little narrower at the base than at the middle. They show on the whole considerable resemblance to those in *Cirolana*, but still differ in several features ; and nearly all the differences may be considered as reductions from the type of the *Cirolaninæ*. About their proximal two-thirds are directed obliquely forwards and somewhat inwards and downwards ; the distal third turns strongly towards the middle line ; their direction presents therefore a stage intermediate between those in *Cirolana-Eurydice* and *Alcironinæ*. Their condylus outside the lateral margin of the labrum is short. The cutting-edges are less produced, and therefore shorter than in *Cirolana-Eurydice*, meeting both above and behind the labrum as in these genera ; the posterior angle is acute and very little produced in both mandibles, but the two other teeth seen on the cutting-edges of the genera mentioned are not present in *Anuropus*. The lacinia mobilis (Pl. 4. fig. 3, *l*) is rudimentary ; the margin between the cutting-edge and the molar process (Pl. 4. fig. 3, *m*) is long, slightly convex, and—as far as could be observed without dissection—only adorned with a number of very short and thin setæ (comp. *Cirolana*). The molar process (Pl. 4. fig. 3, *m*) is moderately large, compressed, oblong, shaped nearly as in *Eurydice*, but only with fine and short setæ along the anterior margin, and firmly united with the mandible (in *Cirolana-Eurydice* it is movably articulated to the body of the mandible), not even marked off by any suture. Of one of the palpi two joints (*i* in Pl. 4. figs. 1 & 2) have been preserved ; the second joint is shorter than in *Cirolana-Eurydice*.

Maxillulæ (first pair of maxillæ, auctorum) (Pl. 4. fig. 2, *l* ; fig. 4).—These agree closely with those in *Eurydice*. The lobe of the first joint (l^1) is well developed, distally rather robust, with three long, plumose spines. The lobe of the third joint (l^3) is very broad, its oblique terminal margin has a number of partially thick spines. (The basal portion of this appendage could not be studied without a dissection.)

Maxillæ (second pair of maxillæ, auct.) (Pl. 4. fig. 2, *m*; fig. 5).—These are somewhat shorter than the maxillulæ, but yet rather large. They differ from those in *Eurydice* only in one point: the lobe of the third joint (l^3) is a single moderately broad plate, while in *Cirolana-Eurydice* it is divided into two parallel lobes, together as broad as, but proportionately longer than, that in *Anuropus*. The lobe of the second joint has four long and strong, plumose setæ, the lobe of the third joint four shorter setæ.

Paragnatha (or *hypopharynx*) (Pl. 4. fig. 2, *k*).—These are a pair of plates which are turned strongly outwards; each is a little longer than broad, with the anterior margin rounded. As compared with those in *Cirolana*, they are a little broader and very much shorter, turning considerably more outwards, and without any produced and curved terminal portion.

Maxillipeds (Pl. 4. fig. 2).—These are thick, do not reach the distal end of the outer lobe of the maxillulæ, and they are in other respects very reduced. The basal joint (*n*) and its large epipod (*o*) as developed as in *Cirolana*. The second joint is formed by the fusion of the second and third joints in *Cirolana*; it is moderately short, and does not possess any trace of the lobe (frequently with coupling-hooks) developed in *Cirolana-Eurydice*. The palpus consists in *Cirolana* and closely allied genera of four joints; in *Anuropus* all these have been completely fused without traces of sutures, constituting one large oblong joint, with some short setæ on the lower side near the inner margin; and this joint shows even tolerably the general outline of the four-jointed palpus in the genera mentioned.

Thorax and its Legs.—Figs. 1 and 2 in Beddard's work convey a sufficient idea of the shape of the thorax with its "epimera"; it scarcely needs mention that the suture, drawn in his fig. 2, between the first segment and its epimeron does not exist. The first pair of legs (Pl. 4. fig. 6) are very robust, to a certain degree developed as a prehensile organ; the third joint (the not-developed epimeron considered as the basal joint) is thick, the fourth short and thick, the fifth very short, the sixth rather long and thick; the seventh joint (*7*) is nearly claw-shaped, but yet slightly curved, and can be folded inwards along the lower surface of the sixth joint; it terminates in a real claw (*c*), which is exceedingly short, acute. Of the six other pairs of legs only one leg, of the fourth pair, was almost completely preserved, and it agrees in all essential points with the same leg in some species of *Cirolana*; its four distal

joints with a number of short setæ and spines is shown in fig. 7 ; the seventh joint (7) is only about one-fourth the length of the preceding joint; the claw was broken off, but it can be said with certainty that it must have been very short. Of all the other legs at least one joint and often more joints were absent ; but these fifth pairs seem to have differed only in quite unimportant features, for instance as to length, from the fourth pair. Beddard's fig. 2 shows all the legs, but in the text he states that the distal joints of the second pair were missing ; the figure is moderately good, but it must be mentioned that the terminal joint of the legs is too long.

Abdomen and its Legs.—The abdomen has been moderately well drawn in Beddard's fig. 1. It increases gradually somewhat in breadth from the base to the middle of the sixth segment ; the five proximal segments are subequal in shape, and similar to the same segments in the males of some species of *Eurydice,* with the exception that in the last-named genus these segments do not increase in breadth posteriorly. The sixth segment is a large shield, nearly circularly rounded on the sides and behind, without hairs or spines on the posterior margin.

The five pairs of *pleopods* are shaped about as in *Cirolana* ; both rami of the same pair and the rami of all pairs are similar in quality and without marginal hairs. In the first pair the inner posterior angle of the peduncle has a series of more than ten coupling-hooks ; such hooks are also present on the second, third, and fourth, but not on the fifth pair. The *uropods* originate close behind the anterior angle of the segment on its lower side near the lateral margin ; the outer edge of the peduncle protrudes beyond that margin. The peduncle is very small, very short, and rather narrow ; the postero-interior process is short. The inner ramus reaches nearly to the hind margin of the abdomen ; it is oblong-ovate, a little longer and a little narrower than the outer ramus ; both rami are similar in quality to those of the pleopods. It has been pointed out by Beddard that the uropods have a respiratory function as the rami of the pleopods, and are concealed beneath the last abdominal segment.

Length and Sex.—The specimen measures, as stated by Beddard, 70 mm. in length. It has no trace of marsupial lamellæ or of " appendix masculina " on the second pair of pleopods. I forgot to look for genital processes on the last thoracic segment, and

I am therefore unable to state with certainty whether it is an immature female or perhaps an immature male.

Position in the System.—The preceding description (with the figures) shows that my statement in 1890—which has been quoted above—on the probable position of this aberrant genus is tolerably correct. After the examination of the type I am now much better acquainted with the genus, having studied all features—especially the mouth-parts and the terminal part of the thoracic legs—of any importance to a final judgment as to its relationship ; and besides I am familiar with all the subfamilies and main genera of the Cymothoidæ.   But in spite of this knowledge, I am still rather uncertain whether I shall refer the animal to the *Cirolaninæ,* or establish it as a type of a new subfamily, *Anuropinæ.*   It is easily seen that it is very distinct from four of the subfamilies—*Corallaninæ, Barybrotinæ, Æginæ,* and *Cymothoinæ,* and that its mouth-parts show a much closer resemblance to those of the *Cirolaninæ* than to the *Alcironinæ,* only the moderately oblique direction of the mandibles and the strongly-reduced maxillipeds without lobe from the second joint pointing towards features met with in the last-named subfamily. The structure of the legs with their very short claws agrees essentially with that in *Cirolana.*   The shape, position, and respiratory function of the uropods is an adaptation to be compared with the supplementary branchiæ in the genus *Bathynomus* which belongs to the *Cirolaninæ,* and that character is therefore of secondary value ; the disappearance of the eyes is also certainly an adaptation and of secondary importance, being at most only of generic value.   The reduction of the antennulæ is very interesting ; it is certainly an excellent generic character, but scarcely an important one for a subfamily, and nearly all the features in which the mouth-parts differ from those of the *Cirolaninæ* sens. strict., and especially from *Eurydice,* seem to be mere reductions.   While the maxillulæ agree closely with those of *Eurydice,* the maxillæ differ as to one not very important point ; and the mandibles, though showing some reductions and a more oblique direction, agree moderately well with those in *Eurydice* in essential points—the distal breadth of the mandible, the breadth of the cutting-edge, the shape of the molar process. The maxillipeds are much more reduced than in *Cirolana-Eurydice* ; the paragnatha are much shorter, rounded distally, &c.

My reason for proposing to establish *Anuropus*, Bedd., as the type of a new subfamily, *Anuropinæ*, is that *the differences between its mouth-parts and those of the Cirolaninæ* are so pronounced, that it may be considered *a practical arrangement* to remove *Anuropus* from the last-named subfamily, which will now be a much more uniform and more sharply-defined group.   But it is possible that in the future some form may be discovered which will prove to be a transition between *Eurydice* and *Anuropus*; and after such a discovery the subfamily *Anuropinæ* ought to be withdrawn.   It is scarcely necessary to compile from the description of the mouth-parts a conspectus similar to that of the *Cirolaninæ* on pp. 310–311 of my earlier paper; when in the future many new forms of the various subfamilies have been studied, at least a few alterations in some of my earlier diagnoses of the subfamilies will most probably be necessary, and every student of the family can then easily compile a diagnosis of the *Anuropinæ* from my description and the drawings.

II. Bathynomus giganteus, *A. Milne-Edwards*.

In July this year (1902) Professor E. L. Bouvier published a very valuable and splendidly illustrated work: " Les Bathynomes," par Alphonse Milne-Edwards et E. L. Bouvier (Reports on the Results of Dredging under the supervision of Alexander Agassiz, by the U.S. Coast Survey Steamer ' Blake ': Memoirs Mus. Comp. Zool. at Harvard College, vol. xxvii. no. 2, pp. 128–175, pls. 1–8).   Bouvier states in a footnote that he had found an earlier sketch (consisting of three large drawings) treating of *Bath. giganteus* among the papers of the late Prof. Alph. Milne-Edwards; but it is evident that at least the main part of the work has been done by himself.   He has produced a very detailed report on the external structure of one American specimen of *Bath. giganteus*, A. M.-Edw., and of the two hitherto known specimens of *B. Döderleini*, Ortm., and he discusses very thoroughly the systematic position of this exceedingly interesting genus.   The Zoological Museum in Copenhagen has obtained by exchange one specimen of *B. giganteus* from the Museum in Calcutta; it was captured in the Bay of Bengal, " off Goa coast, 740 fathoms."   Working on *Anuropus*, I thought it practical besides to look at the external structure of our specimen of

2*

Bathynomus. I must begin with the statement that I can con-
tribute only two or three small additional and a few critical
remarks to the beautiful and exhaustive treatment by Bouvier,
to which the reader is referred.

The specimen seen by me is an immature female, measuring
193 mm. in length, with five pairs of rudimentary marsupial
lamellæ, the longest of which, the fourth, measures only 7·5 mm.
in length and 4·5 mm. in breadth. A comparison with the
figures in Bouvier's work shows that it belongs to *B. giganteus*,
and does not even present any deviating feature in the "epimera,"
the abdomen, &c., worth mentioning.

Dorsal Organ on the Head.—In the figure on pl. 1 in
the French work, showing the animal from above, is seen a
whitish spot in the central line of the head at a short distance
from its posterior margin. A closer examination shows that
this spot must be a kind of organ. The brownish chitine
around the whitish spot (Pl. 4. fig. 8) is glabrous, without the
numerous irregular impressed points adorning nearly the whole
surface ; the spot itself is slightly arched, presenting a small
central oblong impression, and on each half a very small group of
very fine impressed dots. I know nothing of the nature of this
organ. It is probably homologous with the curious organ pointed
out on the upper surface of the head of *Anaspides Tasmaniæ*,
G. M. Thoms., by W. T. Calman (Calman, " On the Genus
Anaspides, &c.," Trans. Roy. Soc. Edinburgh, vol. xxxviii. part iv.
1896, p. 788). I have searched for this organ on a few species of
Cirolana, and found a vestige of it in *Cir. borealis*, Lilljeb.   I
hope in the near future to publish a note on the two organs in
various Malacostraca.

Antennulæ.—Bouvier has made an interesting discovery : he
points out the existence of an accessory ramus originating from
the third joint of the peduncle of the antennulæ, and consisting
of only one very small joint. I can only confirm his description.
I have now looked in vain for an accessory ramus in some species
of *Cirolana* ; so far as I know, it has not been observed in any
other Isopod, but it is well developed in *Apseudes* and the major
part of *Amphipoda Gammaridea*. The short setæ on the joints
of the flagellum mentioned by Bouvier (p. 144) are the sensory
(olfactory) organs.

Antennæ.—The French author writes (p. 144) :—" Les pédon-
cules antennaires (pl. iv. fig. 7), comme dans la plupart des

Isopodes, se composent de 6 articles.   Le premier est immobile, interrompu en dessus à la base des antennules, et forme en arrière un prolongement triangulaire entre les parties latérales du clypeus et la partie inférieure de la région céphalique.   Le deuxième anneau est mobile . . .''   These statements and the figure mentioned are partly incorrect.   In 'Isopoden, Cumaceen, und Stomatopoden der Plankton-Expedition' I have written (p. 4) : '' Bei *Asellota* hat der Stiel der Antennen 6. *Glieder* (ein Charakter, der bei *Mysidæ veræ* sich wieder findet) und oftmals ein rudimentäres Squama auf dem 3. Gliede . . . . . . Bei allen andern Isopoden . . . . ist der Stiel der Antennen höchstens 5-gliedrig (das 1. Glied ist mit dem Kopfe vereinigt), ohne Squama, . . .''   But I discover now that *Bathynomus* disagrees with these statements of Bouvier and of myself : the antennal peduncle consists certainly of *six joints, but all are movable.* What has been considered by Bouvier as the first, immovable joint is a portion of the head (Pl. 4. fig. 9, *a*), not marked off posteriorly as in his fig. 4 ; furthermore he has overlooked the real first joint.   This joint (Pl. 4. fig. 9, *1*) is a rather narrow longitudinal strip of hard chitine, situated on the lower side of the head outside the second joint; when I turned the peduncle of the antennæ backwards and inwards, this basal joint was very conspicuously moved, and the faculty of movement indicates the presence of an articular membrane between the hard strip and the skeleton of the head.   My fig. 9 shows an anteriorly narrow, posteriorly broad articular membrane between this basal joint and the second one (*2*), and besides a well-developed articular membrane between the posterior margin of the second joint and the head.   The position of the first joint is quite as in *Eurycope* (comp. fig. 3 *b* on pl. 20 in my report on the Crustacea in 'Dijmphna-Togtets zoologisk-botaniske Udbytte,' Kjöbenhavn, 1887) and other *Asellota*, but it is proportionately considerably shorter.   The third and following joints have been correctly described and figured by Bouvier.

After the discovery of the basal movable joint in *Bathynomus*, I examined the antennæ in *Cirolana elongata*, H. M.-Edw., *C. borealis*, Lilljeb., and *C. Cranchii*, Leach (three species representing different groups of that extensive genus), and I was now able to find the same basal joint at the outer margin of the following one.   It is especially well developed in *C. elongata*, but also distinct in the two other species ; when the lower surface of

the head is quite dry, and the peduncle is bent backwards and somewhat inwards, it is lifted out of a depression at the base of the antennæ.

Maxillulæ (first pair of maxillæ, auct.).—Bouvier writes (p. 148): " Elles ressemblent beaucoup aux mâchoires des Cirolanes qu'a figurées M. Hansen, mais présentent trois articles basilaires (1, 2, 3), dont deux s'articulent avec la petite lacinie (*l, i*) ; il est probable que ces deux articles correspondent à celui que M. Hansen désigne avec no. 1." His fig. 6 on pl. 5 represents the basal portion of the appendage and is certainly correct, but his interpretation of the parts is incorrect. The joint considered by Bouvier to be the second is in reality the first one : it is pro- portionately long and *is articulated with the skeleton of the head* ; an examination of a *Cirolana* or, still better, of a large specimen of *Chiridothea* will easily prove this fact. The part regarded by Bouvier as the first joint is the basal section of the lacinia proceeding from the anterior and lower side of the elongate first joint, and it is, besides, distant from the skeleton of the head. The result is that the first joint of Bouvier must be put aside, and we have then the three joints described by me in the paper on the Cirolanidæ (1890), in ' Dijmphna-Togtet ' (three figures on pl. 20), and elsewhere. That my view respecting the three joints is correct is easily proved by a careful examination of the constituting elements in the same appendage of a large *Apseudes* or an *Anonyx*, in which genera a two-jointed " palp " originates from the outer side of the third joint ; it is still better proved by the study of the maxillulæ in certain larval stages of *Euphausia*, in which not only a palpus but also an exopod (which again disappears during the development) projects from the outer margin of the third joint.

Maxillæ (second pair of maxillæ, auct.).—Bouvier has a figure which is very similar to mine of certain species of *Cirolana*, but as to the interpretation of the chitinous elements he differs largely. It was impossible to prove the correctness of my view in the paper on the Cirolanidæ &c. without producing a minute description of the parts in question, and besides adding a descrip- tion with figure of the maxilla of a *Mysis*. I think it to be out of place here, and, besides, I hope in the near future to work out a paper on the appendages in Crustacea, lower Insects, &c. I will only mention that in *Mysis* an exopod proceeds from the joint considered by me to be the third, but by Bouvier counted

as the second; furthermore, the two laciniæ considered by me
to belong to the same third joint are developed in a similar
way in *Mysis*, which besides possesses a palpus, consisting of a
fourth and a fifth joint, not existing in the Isopoda. The
presence of both this palpus, of the two narrow lobes mentioned,
and of the exopod in *Mysis*, proves that the outer one of the
narrow laciniæ in *Bathynomus*—and other Isopods—cannot, with
Bouvier, be regarded as the exopod. A study of the consti-
tuting elements of the maxillæ in Cumacea, in larval stages of
Peneidæ, &c., will give the same results (comp. my preliminary
morphological paper in ' Zool. Anzeiger,' 1893).

Maxillipeds.—I have nothing to add to the detailed and careful
description of Bouvier. But in reference to the free " joint "
projecting from the upper side of the second joint at its distal end,
he says (p. 151) that " M. Hansen regarde [cet article] comme
une lacinie mais que nous tenons plutôt pour un expodite (*ex*),
dont la base d'attache se serait rapprochée de la ligne médiane,
en passant par dessus l'endopodite." That the joint in question is
a lobe separated by an articulation from the second joint of the
maxilliped is proved by comparison with other Malacostraca.
In *Bathynomus, Cirolana,* and *Chiridothea* (*Glyptonotus*) the
" joint " is marked off by an articulation ; in *Eurycope gigantea*
(' Dijmphna-Togtet . . .' tab. 20. fig. 3 *g*) it is much larger, but
not at all marked off at the base, proving itself to be a lobe from
the second joint of the maxilliped, and it is developed in a
similar way in many other Isopoda (comp. G. O. Sars, ' Crus-
tacea of Norway—Isopoda '). In most *Amphipoda Gammaridea*,
for instance in *Socarnes* (' Dijmphna-Togtet . . . ' tab. 21.
fig. 5 *b*), the same lobe from the second joint has been developed
on the same place and marked off by an articulation, but, besides,
a lobe (in *Socarnes* much larger than the preceding one), not
defined by an articulation, has been developed from the third
joint. In *Mysis* the lobe from the end of the second joint is
rather short but yet plainly seen, and besides a large exopod
projects from the outer side of the same joint near its base.
Therefore I must maintain my earlier interpretation, which, for
the rest, is not original, being set forth by other authors before
the publication of the Crustacea in ' Dijmphna-Togtets zool.-bot.
Udbytte.'

Abdomen.—The French author writes on p. 172 :—" Ils nous
semble que la pièce caudale, avec sa forme semi-circulaire et ses

fortes dents postérieures, permet plus sûrement de distinguer les
Bathynomes des Cirolanes, d'autant que cette pièce est dépourvue
des soies marginales qu'on observe dans la plupart des Cirolanes,
si non chez toutes." But *Bathynomus giganteus* is not without
setæ at the posterior margin of the last abdominal segment.
The large and beautiful figure on pl. 2 in the French work, of
the animal seen from below, shows fine and short hairs between
the marginal processes, and this is quite correct. On the lower
side along the margin between the processes mentioned is
observed a fine transverse furrow, in which a row of thin plumose
setæ are inserted ; the longest of these setæ I have found between
the fourth and the fifth process—the median one taken as the
first—and some of them measured about 1·5 mm. in length. A
large number of these submarginal setæ have been broken off in
our specimen, but on a closer inspection the furrow mentioned
and some of the setæ are everywhere distinctly seen. It may be
added that setæ at the hind margin exist in all species of
Cirolana.

Pleopoda.—In 'Zoologischer Anzeiger,' nos. 420–421, 1893, I
wrote (§ 13) : " Es folgt aus . . . . dass man *drei Glieder im
Stamm von allen gespalteten Gliedmassen bei den Crustaceen als
ein primäres Verhältnis annehmen muss* " ; and I mentioned the
existence of these three joints in the thoracic appendages of the
Phyllopoda, in the natatory limbs of *Argulus*, in the antennæ
and mandibles of certain pelagic Copepoda, in the antennæ and
the thoracic legs of *Nebalia*, in the antennæ of *Mysidæ veræ* and
of some Isopoda, in the maxillulæ and maxillæ of nearly all
orders of Malacostraca. Now Bouvier writes (p. 154) on *Bath.
giganteus* : " Les pléopodes (pl. 6. figs. 1–5, 7) ont conservé
la structure normale des appendices des Crustacés, en ce sens
qu'il se composent (figs. 1, 4) d'une hampe ou sympodite de
trois articles, et de deux lames terminales, endopodite et exopo-
dite "—and next he describes these parts. The gigantic animal
is an excellent object for the study of the joints in the sympods
of pleopoda, while such joints in animals of normal size are
difficult to discover and especially difficult to judge of with
certainty. I have examined the pleopoda of *Bathynomus*, and
can only confirm Bouvier's interesting discovery : it is the first
time that three joints have been pointed out in the peduncle, the
sympod, of abdominal legs. Bouvier says that the interior lobe
of the sympod " est cilié de puissantes soies," and they are drawn

Hansen.

Linn. Soc. Journ. Zool. Vol.XXIX, Pl. 4.

1-7, ANUROPUS BRANCHIATUS, Bedd   8-9, BATHYNOMUS GIGANTEUS, A.M. Edw.
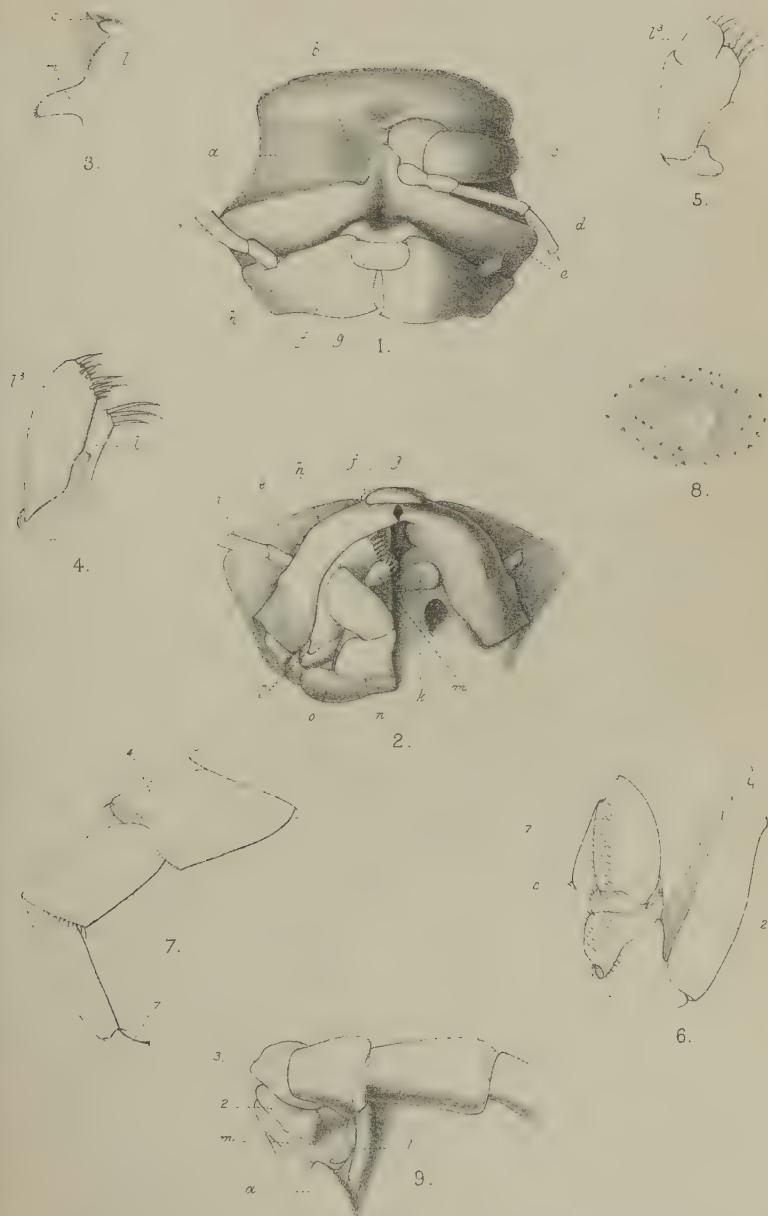
in his fig. 1 on pl. 6, representing the first left pleopod. I will add that these setæ are the coupling-hooks met with in *Cirolana* and most other Isopoda ; in *Bath. giganteus* the anterior hooks are moderately long, the posterior ones exceedingly long, and at least the posterior ones have their apical part so much altered, that I doubt whether they can really be used as hooks coupling together the two peduncles of the same pair. These subsetiform hooks are found, as in *Cirolana*, on the four anterior pairs, but not on the last pair of pleopods. On the shape and structure of the pleopods with their supplementary branchiæ, the reader is referred to the exhaustive account of the French author.

EXPLANATION OF PLATE 4.

Figs. 1–7. *Anuropus branchiatus*, Beddard.

Fig. 1. Head from in front and somewhat from below, × 4. *a*, transverse groove ; *b*, place of insertion of the right antennula ; *c*, left antennula ; *d*, left antenna ; *e*, transverse wall below the groove ; *f*, clypeus ; *g*, labrum ; *h*, mandible ; *i*, mandibular palpus, the third joint broken off.

Fig. 2. Head from below and somewhat from behind. *e*, transverse wall ; *f*, clypeus ; *g*, labrum ; *h*, mandible ; *i*, mandibular palpus without its third joint ; *k*, left wing of the paragnatha ; *l*, maxillula ; *m*, maxilla ; *n*, basal joint of the maxilliped ; *o*, epipod from the basal joint.

Fig. 3. Distal part of the left mandible from below and partly from the inner side. *c*, cutting-edge ; *l*, rudimentary lacinia mobilis ; *m*, molar process.

Fig. 4. Right maxillula from below, the basal part omitted. l^1, lobe from the first joint ; l^3, lobe from the third joint.

Fig. 5. Right maxilla from below. l^3, lobe from the third joint.

Fig. 6. Right leg of the first pair, from below, nearly × 4. *2*, second joint (the first joint fused with the thorax) ; *7*, seventh joint ; *c*, claw.

Fig. 7. Distal part of the right leg of the fourth pair, from below, × $\frac{3}{2}$. *4*, fourth joint ; *7*, seventh joint ; the claw has been broken off.

Figs. 8, 9. *Bathynomus giganteus*, A. M.-Edw.

Fig. 8. Portion of the upper surface of the head, with the organ surrounded by glabrous chitine without impressed points, × 3.

Fig. 9. Basal part of the left antenna, from below and somewhat from the side, scarcely × 3. *1*, first joint ; *2*, second joint ; *3*, third joint ; *a*, skeleton of the head ; *m*, articular membrane.

Some New and Rare Corals from Funafuti.
By G. C. BOURNE, D.Sc., F.L.S.

[Read 4th December, 1902.]

(PLATES **5** & **6**.)

PROFESSOR JUDD has kindly sent me for examination two species of Turbinolid corals and one specimen of an Oculinid coral, dredged from a depth of 200 fathoms off Tutanga, during the recent expedition to Funafuti.

The Oculinid coral, of which only a small fragment was obtained, is undoubtedly *Lophohelia tenuis*, Moseley. So far as I am able to determine, only one specimen of this species has previously been recorded, and that was dredged by the ' Challenger ' from a depth of 375 fathoms between Panglao and Siquijor Islands in the Philippines. The species is distinguished from *L. arbuscula* by the distinct costæ ornamented with longitudinal rows of minute granules, which run down to the basis of the calicles. As Professor Moseley * lamented the inaccuracy of the figure which accompanied his description of this species, I have given in Pl. **5**. fig. 1 an enlarged photograph of the specimen from Funafuti, but the enlargement is not sufficient to show the characteristic granulated costæ. My specimen is smaller than Moseley's, the length of each calycle being 3 mm., and the diameter of the mouths of the largest calycles does not exceed 2 mm.

Of the seven Turbinolid corals sent to me, two are pedunculate and five are free forms. They all have two circlets of pali of unequal sizes, unequal and highly exsert septa, arranged in six systems and four cycles. They belong, therefore, to the subfamily *Trochocyathaceæ*, as defined by M.-Edwards and Haime and subsequently re-modelled by Duncan. I was at first inclined to believe that the pedunculate specimens were the nurse-stocks from which the free forms had been liberated, but closer inspection revealed such differences in the costæ and the granulations on the surfaces of the septa, as to leave no doubt that they belong to distinct species.

The pedunculate specimens must be placed in the genus *Trochocyathus*, as they agree exactly with Milne-Edwards and

* H. N. Moseley, ' Challenger ' Reports, Zoology, vol. ii. 1881.

Haime's definition of that genus:—" Le polypier est simple, pédonculé ou subpédicellé, ou ne présente à sa base que des traces d'une adhérence ancienne. La columelle est bien développée et se compose de tigelles prismatiques ou tordues qui se disposent en faisceau ou en série. Les palis sont bien développés, entiers, libres dans une assez grande étendue, inégaux suivant les couronnes auxquels ils appartiennent ; ils se trouvent devant toutes les cloisons, excepté devant celles du dernier cycle. Les cloisons sont débordantes, larges et striées latéralement ; la muraille est nue ou ne présente qu'une épithèque rudimentaire." As they have simple wedge-like costæ they belong to § A (*Trochocyathes striés*), and as they have six equal systems and four complete cycles of septa they belong to §§ B of the genus.

TROCHOCYATHUS VASIFORMIS, n. sp.   (Pl. 5. figs. 6 & 7.)

Corallum pedunculate and vasiform, fixed by an expanded encrusting base. Calycular fossa oval, fairly deep. Septa in six systems and four complete cycles ; primary and secondary septa subequal in size and conspicuously exsert ; tertiary septa smaller and less exsert ; quaternary septa small, the lateral faces of the septa covered with rows of granules horizontally arranged. Costæ of the first three cycles simple, ridge-like, extending down to the peduncle, those of the fourth cycle shorter and less prominent. Peduncle minutely granular. Pali in two circlets of unequal size ; those of the smaller circlet correspond to the primary and secondary septa ; the larger pali in front of the tertiary septa, large, with lateral lobes and coarse granulations ; no pali in front of the quaternary septa. Columella consisting of from six to eight contorted trabeculæ.

Habitat. Funafuti.

All the species of *Trochocyathus* described by M.-Edwards and Haime are fossil, but a living species, *T. Victoriæ*, has since been discovered by Tenison Woods [*] near Port Jackson, Australia, and Duncan [†] states that another living species has been found in the W. Indies. I am not, however, able to find the authority for the latter statement. The species from Funafuti is distinct, and is an interesting example of a com-

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[*] J. E. Tenison Woods, Proc. Linnean Soc. N. S. Wales, ii. 1878, p. 304.
[†] P. Martin Duncan, Journ. Linn. Soc., Zool. xviii. 1884, p. 22.

paratively deep-sea form of which the allied species are, with two exceptions, found only in the fossil state.

The larger of my specimens is attached to a dead and corroded specimen of the same species, and looks at first sight as if it had been budded off from it. But it is clear on close examination that this is a case of simple attachment, and the coral is solitary and not compound. This specimen measures 20 mm. in height ; the greater diameter of the calyx is 12 mm. and the lesser diameter 10 mm.

The second specimen is smaller, the calyx measuring 7×6 mm., and the fourth cycle of septa is incomplete, consisting of 18 septa only. This is clearly a young individual in which the fourth cycle is not yet fully developed ; and it is worth noting that the quaternary septa that are present are regularly arranged in pairs, embracing the tertiary septa, and three such pairs are missing, namely, one in the right sulcular and one in each of the right and left sulcolateral systems. In other words, the order of appearance of the septa of the fourth cycle does not conform to Milne-Edwards and Haime's law, as is so frequently the case in other corals. This specimen is attached to a dead fragment of a *Lophohelia* ; and a very small and young *Trochocyathus* is growing on the same fragment, having six larger primary septa, six smaller secondaries, and only an indication of the tertiaries.

The five free Turbinolids are characterized by the presence of five (in one specimen six) long and slender spines projecting outwards and downwards from the lower moiety of the calyx. They show some resemblance to *Deltocyathus italicus*, var. *calcar* of Pourtales, but differ from that species in not possessing the characteristic deltoid pali. They are clearly very closely related to *Turbinolia Mantelli*, figured but not described by G. A. Mantell, in a paper on the Geology of New Zealand, in the Quarterly Journal of the Geological Society of London, vol. vi. 1850, pl. 28. fig. 18. Milne-Edwards and Haime record this species among the doubtful forms of *Trochocyathus* as *Trocho-cyathus* (?) *Mantelli*, and call attention to its close affinity to *Trochocyathus armatus*, Michelotti, and *T. perarmatus*, Tallavignes. I have not been able to refer to Michelotti's figures of *T. armatus*, but it appears from the description to differ from my specimens in the shape of the calyx and the character of the pali ; while Rouault's figure of *T. perarmatus*,

a species differing from *T. armatus* only in possessing six spines instead of five, shows deltoid pali, and the spines are much shorter and thicker than in my specimens. Mantell's figure of *T. Mantelli* shows only the base of the specimen, the mouth of the calyx being imbedded in the rock in which it was found, but, as far as can be seen, the proportions of the spines and the characters of the costæ agree very closely with my specimens. In the absence of a description and of any information about the characters of the septa and pali, it is not possible to say whether the species are identical or not.

Dennant's *Stephanotrochus Tatei*, though superficially extremely like the Funafuti specimens, differs entirely from them in the arrangement of the septa and in the absence of pali (Trans. Royal Soc. S. Australia, xxiii. 1898, p. 117, pl. 3. fig. 1, *a–e*).

I must therefore describe the Funafuti specimens as a new species.

TROCHOCYATHUS HASTATUS, n. sp. (Pl. 5. figs. 2–5.)

Corallum free, short, bowl-shaped, with a scar of attachment at its base. Calycular fossa oval, deep. Septa in six systems and four cycles, the fourth sometimes incomplete. The primary septa somewhat larger than the secondaries, both very exsert; the tertiary and quaternary septa smaller and less exsert; the faces of the septa covered with prominent pointed granulations arranged in radiating rows. Costæ broad, closely crowded together, of nearly equal width, extending down the upper two-thirds of the calyx, covered with fine granulations. The costæ of each primary septum with the two quaternaries adjacent to it produced outwards to form six long horizontally projecting tapering spines; in cases in which five spines only are present, the deficiency occurs at one end of the long axis of the calyx. The base of the corallum smooth, and often nacreous in appearance. Pali in front of the primary and secondary septa small and inconspicuous; those in front of the tertiary septa large, prominent, and covered with spiniform granulations. Columella relatively small, consisting of from 10–12 contorted trabeculæ.

Habitat. Funafuti.

Of the five specimens of this species, one, a dead and worn example, has six spines corresponding to the six primary septa, the others have five spines. The number of spines being

variable in this case, it seems probable that *T. armatus*, Mich. and *T. perarmatus*, Tallavignes, are only varieties of one species. *T. Mantelli* has six spines. It is remarkable that two quaternary costæ cooperate with each primary costa in the formation of a spine, and in one case as many as five costæ unite to form a spine, viz., one primary, one tertiary, and three quaternary. In three specimens the fourth cycle of septa is complete, in the other two specimens two quaternary septa are missing in one of the systems adjacent to the long axis of the calyx, and in each case the tertiary septum, which they would, if present, have embraced, is devoid of a palus. But the missing quaternaries are not adjacent to the primary septum, which is devoid of a spine, as described by M.-Edwards and Haime for *T. armatus*.

The following are the measurements of the five specimens :—

			mm.			mm.			mm.
A. Depth of calyx, 12				Longer diameter, 18			Shorter diameter, 16		
B.	,,	,,	12·5	·,	,,	15·5	,,	,,	13·5
C.	,,	,,	11	,,	,,	15·5	,,	,,	13·5
D.	,,	,,	9	,,	·,	13	,,	,,	12
E.	,,	,,	11·5	,,	,,	16·5	,,	,,	15

Note.—Since this paper was written Dr. A. Alcock has published an account of three species of corals, very similar to the form described above as *Trochocyathus hastatus* (Report on the Deep-Sea Madreporaria of the 'Siboga,' Expedition, Leiden, 1902). Two of these he has described under the names of *Odonto-cyathus sexradiis* and *Odontocyathus stella* ; the third specimen he has not named because it was in too imperfect a condition for accurate diagnosis.

When my paper was read before the Linnean Society it was naturally suggested that, as the Funafuti specimens are so very similar to those described by Dr. Alcock, they might belong to one of his species, and certainly to the genus *Odontocyathus*, Moseley.

The Funafuti specimens which I have named *Trochocyathus hastatus* differ from *Odontocyathus sexradiis* in the following particulars : the primary septa are not so conspicuously exsert ; the edges of the bowl-shaped corallum are not scalloped ; there are only four cycles of septa, instead of five and parts of a sixth as in *O. sexradiis* ; the pali in front of the tertiary septa are by

far the largest (in *O. sexradiis* " the pali of the innermost crown are the smallest ").

Trochocyathus hastatus differs from *Odontocyathus stella* in being bowl-shaped, whereas the latter species is flat, in the 2nd cycle of septa being large and nearly as exsert as the 1st cycle, whereas in *O. stella* the 2nd cycle is least exsert of all but the quaternaries, and in the character of the pali. So far as can be ascertained from the meagre description, *T. hastatus* is also quite distinct from the unnamed specimen.

There is, therefore, no question of identity of species, and I have only to consider whether the Funafuti specimens should be classed, along with the Siboga specimens, in the genus *Odontocyathus*. Having fully considered this question before Dr. Alcock's paper came into my hands, I see no additional reasons for altering my original opinion that the Funafuti specimens should be placed in the genus *Trochocyathus*, M.-Edw. & H., and not in the genus *Odontocyathus*, Moseley.

I have no doubt that the Siboga specimens should be placed in the same genus as those from Funafuti. Their affinities are obvious. But I consider that Dr. Alcock is in error in placing them in the genus *Odontocyathus*. This genus was established by Moseley to receive a deep-sea turbinolid having *twelve* stout spines irregularly beset with small pointed tubercles, the spines corresponding to the primary and secondary costæ. In the Siboga and Funafuti corals there are *six* or *five* smooth spines corresponding to the six primary costæ. In Moseley's *Odontocyathus* the twelve radiating basal ridges corresponding to the twelve spines reach to the central basal scar and are covered with tubercles, a feature which is absent in the Siboga and Funafuti specimens. In fine, a glance at Moseley's figures is sufficient to satisfy one that neither Dr. Alcock's specimens nor mine have any close resemblance to *Odontocyathus*—though all these forms come under the definition of the *Trochocyathes armés* of Milne-Edwards and Haime.

It was not, and it is not now, my intention to criticise Moseley's genus. He said that his coral was of such a peculiar shape that a new genus must be created for its reception. If we accept his genus, we must regard the twelve spines and the basal tubercles as diagnostic characters, for there are no others to distinguish it from the genus *Trochocyathus*. These diagnostic characters are not shared by the Funafuti and Siboga specimens.

Should we, then, place them in the genus *Trochocyathus*, or create
a new genus for their reception ?   After considering this point
carefully, I decided that there was no occasion for creating
a new genus, for there are no characters, either of septa, costæ,
costal spines, basal scar, pali, or columella, which do not come
under the definition of the genus *Trochocyathus* as given by
Milne-Edwards and Haime, a definition which has never been
altered by any subsequent authority.   In these days, when
a series of imperceptible gradations is held to be a good reason
for uniting species formerly considered distinct, it is no time
to establish new genera among forms connected by equally
imperceptible gradations.

    28*th January*, 1903.   G. C. B.

[ADDENDUM.—It was only after this paper had been sent to
the press that I received three discoid corals which, on account
of their small size, had been overlooked, and were found again
when the collections from Funafuti were being finally sorted for
distribution to various museums.

    The specimens in question are minute discoid forms, the
largest measuring 4 mm., the smallest 3 mm. in diameter.   In
the smallest specimen there are six costæ, corresponding to six
primary septa, which are more prominent than the rest ; in the
two larger specimens there are six distinct but short and stout
costal spines, corresponding to the six primary septa.   Coming
as they do from the same locality, these small discoid corals may
safely be identified as the young forms of *Trochocyathus hastatus*.
They are of considerable interest, for they show that the free
forms of this species are derived by strobilization from a nurse-
stock or trophozooid, and that the arrangements of septa, pali,
and spines characteristic of the adult are the result of secondary
growth after the young forms have separated from the nurse-
stock.

    The three specimens are shaped like flat discs, the smallest
being rather less than 1 mm., the largest about $1\frac{1}{2}$ mm. in
thickness.   The upper and lower surfaces of each present a large
scar of attachment, extending over nearly the whole diameter of
the disc.   On one surface, which may be called the lower
surface, the interseptal loculi are more or less filled up with
a compact calcareous deposit, so that the outlines of the septa
are obscured or hardly distinguishable.   On the other surface

there is a distinct calycular fossa, but, excepting in the largest specimen, the septa scarcely project above the surface of the disc, and their upper edges give evidence of their having been recently severed across.

The flat discoid shape of these young corals and the presence of a large scar of detachment on their upper as well as on their lower faces show that they are not pedicellate forms that have simply been detached at the base, as is the case in several species of *Flabellum*, but that they must have formed by the transverse division of a fixed nurse-stock, just as the ephyræ of *Aurelia* are formed from a strobila. Such a process of strobilization is extremely rare in corals, but it has been described by Semper * in *Flabellum variabile*. It is not exactly the same thing as the formation of anthocyathi from the trophozooid of *Fungia*; for in the latter case the margins of the calycle of the trophozooid expand laterally to form a broad disc-shaped *Anthocyathus* before detachment takes place. The theca of the *Anthocyathus* is on the lower surface, and the scar of detachment is small relatively to the diameter of the *Anthocyathus* itself. After the first *Anthocyathus* is detached a new one is formed by the upgrowth and subsequent outgrowth of the septa within the scar at the upper end of the trophozooid, and this is in turn detached, the process being repeated three or four times, but not more so far as is known. In *Trochocyathus hastatus* the thecal walls of each disc-shaped young specimen are nearly vertical, and the scar of detachment is nearly as large as the disc itself. Moreover, it is clear that the young forms are not successively completed and then detached, as in *Fungia*, but that a number of young forms are segmented off from the trophozooid, either simultaneously or in rapid succession, before the septa have time to grow or to repair their divided edges.

The smallest of the three specimens from Funafuti appears to be the most recently detached of the three. It measures rather less than 3 mm. in diameter and 1 mm. in thickness. The upper and lower surfaces are flat, and the margin of the disc constituting the theca is evenly rounded and marked with thirty-six costæ, having the form of low ridges (Pl. **6**. fig. 8). Six of these costæ are somewhat more prominent than the rest,

* Zeitschrift für wissenschaftliche Zoologie, Bd. xxii. p. 235.

but are not yet developed into spines. In the large scar on the
lower surface of the disc, thirty-six septa, corresponding to
the thirty-six costæ, and a central columella can be more or less
distinctly seen, but the interseptal loculi and the central cavity
are already largely filled up by a compact calcareous deposit, so
that the outlines of the septa are blurred and difficult to make
out.   On the upper surface, on the other hand, there is a
distinct calycle in which the septa are conspicuous and the inter-
septal loculi are relatively deep.   The centre of the calycle
is occupied by a fascicular columella consisting of numerous
irregularly shaped calcareous nodules, the more peripheral of
which are sometimes united with the inner ends of the larger
septa, but there are no pali.

The thirty-six septa are arranged in six systems and four orders,
those of the first three orders forming complete cycles. The
septa of the first order correspond to the six more prominent
costæ, are larger and extend further towards the centre of the
calycle than those of the other orders.

The second and third orders are complete, comprising six and
twelve septa respectively.   The fourth order is incomplete,
comprising only twelve septa, and in each system the septa
of the fourth order are situated in the loculi between the septa
of the first and third ; there are no quaternary septa in the
loculi between the secondaries and tertiaries.   There is little
difference in size between the secondary, tertiary, and quaternary
septa.   If anything, the tertiary septa are rather longer than
the secondary, and in some of the systems the quaternaries are
as large as or larger than the tertiaries.

Though the costæ are fairly prominent, the upper edges of the
septa stand but very little, if at all, above the level of the disc.

An outline of one of the primary septa is given in fig. 8 a.   It
can be seen that the upper edge is horizontally truncated, giving
evidence of its recent severance from the corresponding septum
of the individual next above it during strobilization.   But
although the severance is obviously recent, sufficient time must
have elapsed for processes of repair and regrowth to have set in,
for on the upper margin there are calcareous granules which, as
is evident on microscopical examination, have been recently
deposited on the truncated edge.   Similar granules are discover-
able on the upper edges of all the septa, showing that the
process of regrowth has already begun.

The second specimen measures rather less than 3·75 mm. in diameter, and is evidently somewhat older than the first. The costæ corresponding to the six primary septa are produced into as many stout conical spines (Pl. **6**. figs. 9 & 10), but the remaining costæ are not so prominent as in the first specimen, as the theca has been thickened by a secondary deposit, probably of an epithecal character. The lower surface of the disc is perfectly flat and presents a large scar, in which the septa and columella are distinguishable, though the spaces between them are filled up with secondary calcareous deposit.

On the upper surface the calycle is somewhat deeper than in the first specimen, and the septa are slightly more exsert. The columella also is more abundant, but there are no distinct pali. As in the first specimen there are six systems, and three complete orders and a fourth incomplete order of septa. In this specimen the septa do not reach so far towards the centre of the calycle as in the first, but the primaries are distinctly the longest. Although the septa project but very little above the level of the disc, their upper edges have evidently advanced further in regrowth than was the case in the first specimen: they are no longer horizontally truncated, but are rounded and produced into tiny projecting spinose granules. The process of regrowth has been most rapid in the tertiary, least rapid in the secondary septa, so that the last named are now the smallest of all the cycles. Further, it may be observed that while the costæ of the secondary and quaternary septa are very inconspicuous, those of the tertiary septa have increased in size, and form two prominent swellings or ridges between every two adjacent spines. In other words, the tertiary septa have grown faster than the others, and it should be borne in mind that it is in connection with the tertiary septa that the conspicuous crown of pali, characteristic of the adult specimens of *T. hastatus*, is developed.

The third specimen measures 4 mm. in diameter, and is considerably further advanced in growth than the other two. The six spines, corresponding to the primary septa, are not much larger than in the second specimen, but the disc is thicker and the scar on the lower surface is so completely filled up with the secondary deposit that only a circular depression is left, corresponding very nearly in size and appearance with the scars

3*

visible on the under surfaces of the adult specimens of
T. hastatus.

Associated with the filling up of the scar is a considerable
extension of the epithecal deposit on the lower surface,
obliterating the costæ, and giving the same nacreous lustre
to this region as is seen in the adult specimens. This specimen
was apparently dead when collected and had suffered some
erosion and injury, for the interseptal loculi are partly filled
up with Foraminifera, and the upper parts of several of the
septa are broken off. I am able, however, to count thirty-six
septa, whose arrangement is identical with that of the first and
second specimens, but they have progressed much further in
growth.

The uninjured septa, as is shown in Plate **6.** fig. 11, project
well above the margin of the calycle and are of unequal sizes.
Those of the first order are the most exsert, then follow those of
the third, then those of the second order, and the quaternaries
are the least exsert of all. The inner ends of the septa are
so much damaged that it is difficult to say anything certain
about the presence of pali, but there are indications of a
prominent inner spine separated by a notch from the main part
of the septa of the first and third cycles, so I am inclined to
think that the pali are being developed at this stage. The
specimen, however, is of great interest, for it clearly indicates
that the greater part of the corallum of the adult *Trochocyathus
hastatus,* with its characteristic arrangement of septa and pali, is
formed by the upgrowth of the septa from the scar of detachment
on the upper surface. In the order of their appearance the
septa follow the law of Milne-Edwards and Haime; that is
to say, that in each of the three first orders the septa appear
simultaneously and form three complete cycles. The septa of the
fourth order are twelve in number and appear in the interseptal
loculi $1+3,\ 3+1,$ in each system forming an incomplete cycle.
The septa of the fifth order appear very late in the interseptal
loculi $3+2,\ 2+3,$ in each system, and with the septa of the
fourth order form a complete fourth cycle. But during the
growth from the young to the adult form, the rate of growth
of the septa does not follow this law. The six primary septa are
always predominant in size, but the secondaries, which in adult
specimens are equal or nearly equal to them, lag behind in the
earlier stages of regrowth, and are surpassed by the tertiaries,

CORALS FROM FUNAFUTI.

9

8a.

9a.

8

11

10
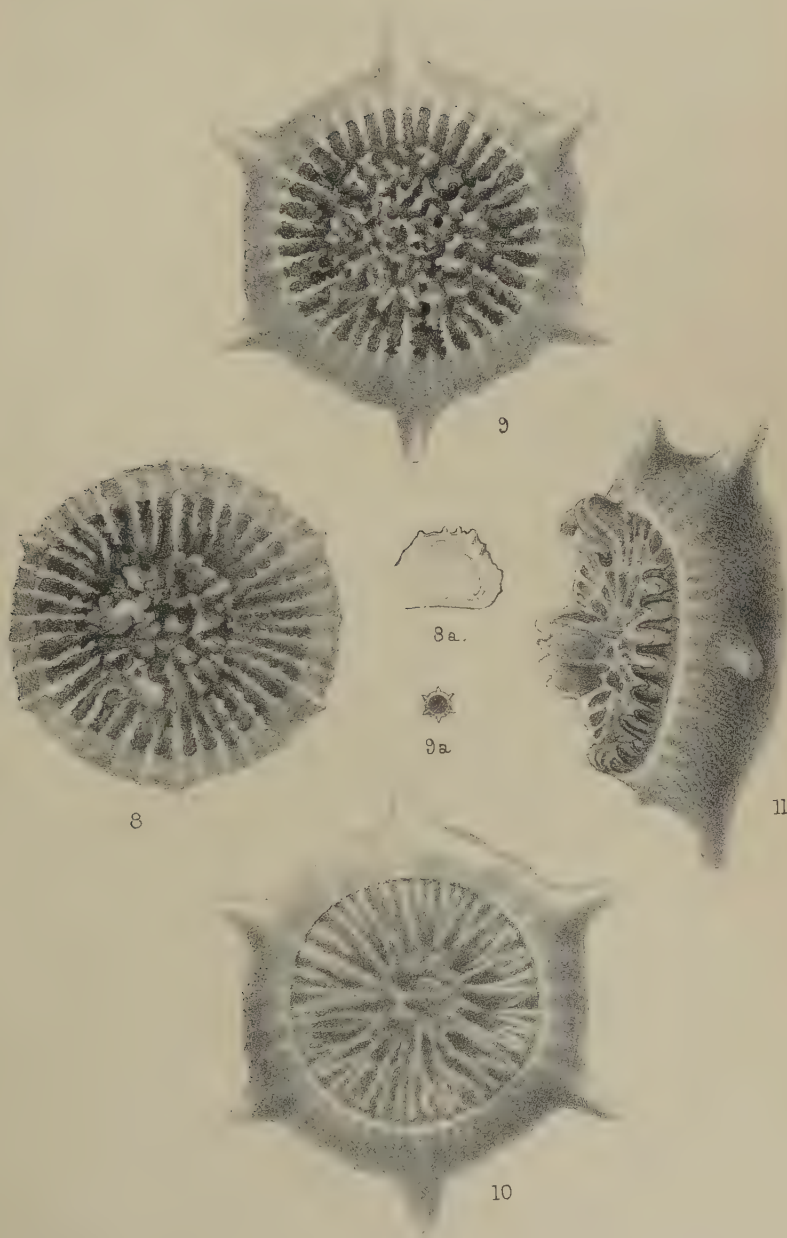
this variation in rate of growth being doubtless associated with the great size of the pali belonging to the last-named cycle. It is a peculiarity that where there is an irregularity of growth leading to the suppression of one of the six spines, it is always associated with the suppression of one of the tertiary septa and its palus together with the septum of the fifth order adjacent to it.

10th March, 1903.   G. C. BOURNE.]

DESCRIPTION OF THE PLATES.

PLATE 5.

Fig. 1. *Lophohelia tenuis*, Moseley, enlarged.
2. Side view of *Trochocyathus hastatus*.
3. Basal view of the same species.
4. Enlarged view of the calyx of the same species.
5. Calyx of a 6-spined individual of the same species.
6. Lateral view of *Trochocyathus vasiformis*, n. sp.
7. Calyx of the same species, showing septa and pali.

PLATE 6.

Fig. 8. Enlarged view of the upper surface of the youngest specimen of *Trochocyathus hastatus*, showing thirty-six septa divided into six systems and four orders. The six primary septa are larger than the rest but have not yet developed spines.

8 *a*. Lateral view of one of the primary septa of the same specimen showing the horizontally truncated upper edge.

9. Enlarged view of the upper surface of an older specimen of the same species ; the same number of septa is present as in the younger specimen, but conspicuous costal spines are developed in connection with the six primary septa.

9 *a*. The same specimen, natural size.

10. Ventral view of the same specimen, showing the interseptal loculi largely filled up by secondary calcareous deposit.

11. Enlarged lateral view of a still older specimen, which has been somewhat damaged, showing the upgrowth of the septa to form the calycle of the adult.

Amphipoda of the 'Southern Cross' Antarctic Expedition.
By ALFRED O. WALKER, F.L.S.

[Read 18th December, 1902.]

(PLATES 7–11.)

THE Amphipoda which form the subject of this paper were collected during the Expedition of the 'Southern Cross,' commanded by Capt. Borchgrevink, to the Antarctic Seas from April 5, 1889, at Cape Adare, to Feb. 18, 1900, at Franklin Island. By far the larger part of the collection was made after the lamented death of Mr. N. Hanson, the Zoologist of the Expedition, by Mr. Anton Fougner, partly by dredging at depths varying from 10 to 26 fath. and partly on the beach at Cape Adare.

It is impossible not to be struck with the general resemblance of the collection, both as regards the number and size of individuals and the great preponderance of the Lysianassidæ, to such a collection as might be found in the Arctic Seas ; and with the equally great difference in these respects from any collection that might be made under similar conditions of depth, &c., on our own or on tropical coasts.   Although I have only ventured to refer one species to a known Arctic form (*Ampelisca macrocephala*, Lilljeborg, found also on our own coasts), yet I have only had occasion to make a single new genus (*Oradarea*). And several of the new species are only separated from Arctic forms by very slight differences—indeed the genera of the Lysianassidæ have been separated by G. O. Sars on such fine distinctions that the species are reduced to almost infinitesimal differences.   Thus *Orchomenella pinguides* is very near to *O. pinguis*, Boeck ;   *O. Franklinii* to *O. minuta* (Kröyer) ; *Oediceros Newnesii* to *O. saginatus*, Kröyer, &c.   One of the most interesting forms is *Atylus antarcticus*, which differs only in very unimportant details from *A. carinatus* (Fabr.), a species that according to G. O. Sars has only once been taken south of the Arctic Circle, and then in the stomach of a fish !   Yet, with perhaps the exception of *Halirages Huxleyanus* (Bate), which Sars thinks ought to be referred to *Atylus* * (notwithstanding a quite different telson), no other species of the genus as restricted by Sars has been found as yet in the enormous intervening area.

* Crustacea of Norway, vol. i. p. 471 ; *cf.* p. 436.

I have no intention of putting forward any theory to account for the similarity of the two Polar Amphipodal faunas: our knowledge of this class of animals and the material at our disposal are quite insufficient for generalization. But it is worth while to consider the distribution of the small genus *Orchomenopsis*, established by G. O. Sars in his beautiful work on the Amphipoda of Norway in 1895. So far as I know, the following are all the species yet obtained :—

O. obtusa, G. O. Sars. The type. Trondhjemsfiord, 100 fath.

O. (Orchomene) musculosus (Stebbing). 'Challenger.' S. of Japan, N. lat. 26°, E. long. 138°. 2425 fath. Temperature 35°·6.*

O. abyssorum (Steb.). 'Challenger.' E. of Buenos Ayres, S. lat. 36°, W. long. 51°. 1900 fath. Temp. 33°.

    Do.   G. Murray in the 'Oceana,' Nov. 1898 [Ann. & Mag. Nat. Hist. ser. 7, xii. (1903) p. 232, ined.]. N. lat. 52° 18', W. long. 15° 53', 1610 and 1410 faths.

    Do.   Chevreux (Camp. Sci. de l'Hirondelle, p. 23). N. lat. 48°, W. long. 51°. 1103 fath. [Chevreux has also described (Bull. Soc. Zool. France, xxviii. (1903) pp. 93–96) two new species from the North Atlantic.]

O. nodimanus, A. O. Walker. Cape Adare. 26 fath. Temp. 28°·8.

O. Rossi, A. O. Walker. Franklin Island. Surface; lat. 78°35'.

If to these we add, as G. O. Sars is inclined to, *Orchomene cavimanus*, Stebbing, from Kerguelen Island, we shall probably have all the known species. It will be seen that *Orchomenopsis* is distributed over a very large part of the world's area, and that in every case it has been taken in water at a low temperature. In fact this, and not light, appears to be essential to the existence of its species.

Another deep-sea form which has not yet been found in Antarctic waters, but which, I confidently expect, will be, is *Cyphocaris anonyx* from the Greenland coast. In the 'Challenger' Report, Mr. Stebbing describes a species, *Cyphocaris micronyx*, from near Tristan da Cunha, taken in 1425 fath., temp. 37°, which I believe he now considers identical with Lütken's species. And in Mr. G. Murray's 'Oceana' gatherings the same species occurs at depths of 510, 1300, and 1670 faths. These facts appear to support the theory of a connection between the Poles by the cold abyssal stratum of the Ocean.

* Bottom temperature is always to be understood.

Among the Lysianassidæ, notwithstanding the large size of most of the specimens, I have not met with an ovigerous female or a male with fully developed lower antennæ. Probably, like *Amathilla homari* of our own seas, they reach maturity in deep water.

The collection consists of 22 species belonging to the following genera :—

Hyperia	1 species.		
Hyperiella	1	,,	
Cheirimedon	2	,,	new.
Orchomenopsis ..	2	,,	new.
Orchomenella ..	2	,,	new.
Tryphosa	2	,,	new.
Hoplonyx	2	,,	1 new.
Ampelisca	1	,,	
Oediceros	1	,,	new.
Epimeria	1	,,	new.
Eusirus	1	,,	new.
Oradarea, new ..	1	,,	new.
Atyloides	1	,,	
Atylus	1	,,	new.
Liljeborgia	1	,,	
Haplocheira	1	,,	
Jassa	1	,,	new.

AMPHIPODA.

Fam. HYPERIIDÆ.

Genus HYPERIA, *Latreille*, 1823.

H. GAUDICHAUDI, *H. Milne-Edwards*.

Cape Adare, " surface," Nov. 2, 1899, 2 young ♂ ; Nov. 11, 1899, " from jelly-fish caught on surface," 9 specimens, ♂ ♀ and young ; surface, S. lat. 78° 35′, Feb. 18, 1900.

Length of largest female 23 mm.

Genus HYPERIELLA, *Bovallius*, 1887.

H. DILATATA, *Stebbing*, ' Challenger' Amphipoda, p. 1403, pl. 171.

Cape Adare, on the beach, April 5, 1899. Two males.

Length 5 mm.

GAMMARIDEA.

Fam. LYSIANASSIDÆ.*

This appears to be by far the most important family of Amphipoda in the Antarctic, as it probably is also in the Arctic Seas. The number both of species and specimens much exceeds those of any other family, and most of them are remarkable for their great size as compared with their nearest allies from warmer waters.

Genus CHEIRIMEDON, *Stebbing*, 1888,
Chall. Amph. p. 638.

Except as to the posterior angle of the 3rd segment of the metasome, which is not upturned in the following species nor in *C. latimanus,* G. O. Sars.

C. FOUGNERI, n. sp.   (Pl. 7. figs. 1–6.)
Lat. 78° 35′ S.; surface, Feb. 15, 1900.   Many specimens.

Body somewhat compressed. Mesosome segments subequal, those of the metasome about half as long again, also subequal, the 3rd having the hind margin nearly straight, forming approximately a right angle with the lower margin.   First four side-plates about as deep as the segments.

Urosome with a deep dorsal depression in the 1st segment.

Head as long as the 1st segment; lateral angle rounded; eyes irregularly reniform, wider below, dark in spirit.

Upper antennæ as long as the head and next four segments †, the 1st joint of the peduncle about twice as long as wide and as the next two joints; flagellum 27-jointed, the 1st longer than the next three; accessory appendage 6-jointed, the 1st as long as the next four, the last minute.

Lower antennæ about one-fourth longer than the upper, the joints of the peduncle increasing in length distally, rather densely fringed on the lower margin with short setæ.

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* For the definitions of the genera of this family, see G. O. Sars, 'Amphipoda of Norway.'

† The word "united" after "segments" or "joints" must always be understood. Also, in all cases, by "1st joint" of the antennal peduncle is meant the 1st *exposed* joint or the antepenultimate. The "1st joint" of a limb is the *basipodite.*

First gnathopod very robust, the 1st joint rather longer than the 4th and 5th, the 2nd longer than the 3rd and 4th; the propodos expanding slightly distally, as wide as the posterior margin is long, palm slightly oblique and sinuous, and densely fringed with short spines and setules.   Carpus very short. Side-plate widening and rounded below, anterior margin uneven.

Second gnathopod normal: the side-plate oblong with rounded angles.

Peræopods: the first two pairs with the 3rd and 5th joints longer than the 4th.   The 3rd and 4th pairs have the 1st joint wide at the top and produced downwards : in the last pair it is more expanded and widest in the middle, longer than the next three joints : in all three the hind margin is faintly serrate.

Uropods: the 1st and 2nd reach nearly to the end of the shorter ramus of the 3rd; peduncles long and angular, the margins fringed with short spines.   Third pair with peduncle about as long as the inner (shorter) ramus, which, as well as the outer, has a few long setæ on the inner margin; the outer ramus has two spines on the outer margin near the point.

The telson reaches a little beyond the end of the peduncles of the 3rd uropods, cleft with a wide sinus for nearly half its length, a small terminal spine only on each division.

Length 20 mm.

Differs from *C. crenatipalmatus*, Stebbing, in the shape of the 3rd metasome-segment, &c., and from *C. latimanus*, G. O. Sars, in the less widely expanded hand of the 1st gnathopods, the shape of the telson, &c.

Named after Mr. A. Fougner, one of the scientific assistants of the ' Southern Cross ' Expedition, who collected it.

C. HANSONI, n. sp.   (Pl. 7. figs. 7–12.)

Cape Adare, 7 fath., Nov. 1, 1899.   Nine specimens.

Body rather rounded : the first two segments severally shorter than the 3rd and 4th, which again are shorter than each of the last three, each set being subequal.   The first 4 side-plates slightly deeper than the segments.   *Third segment of the metasome with the posterior angle produced and turned up to a rather blunt point*, posterior margin above the angle straight.   First segment of the urosome with an acute dorsal elevation.

Head as long as the first 2 segments, *lateral angle produced beyond the end of the 1st joint of the lower antennæ, acute.* Eyes almost obliterated, apparently oval.

Upper antennæ about as long as the head and first 4 segments; 1st joint thick and as long as the next two and first 2 joints of the flagellum united; flagellum 15-jointed. *Accessory appendage 2-jointed, the 1st nearly twice as long as the 2nd.*

Lower antennæ: first joint short, 2nd and 3rd nearly twice as long, subequal.

First gnathopods: side-plates oblong, narrowing slightly downwards. First joint almost as long as the next four; the 2nd, 3rd, and 4th subequal in length and about as long as the 5th; the 4th triangular and produced behind in a short lobe: the propodos wide, scarcely dilated distally, palm rather oblique, dactylus with a minute secondary tooth near the point.

Second gnathopods as in *C. crenatipalmatus*, Steb.

Peræopods: first and second nearly as in *C. crenatipalmatus*: side-plates of the 3rd rather wider than, but not so deep as the 1st joint, which is oblong and as long as all the remaining joints; the 3rd joint short and wide; dactylus half as long as the 5th joint. The last two pairs resemble the 3rd, but the 1st joint is wider, all being about the same length and with the hind margin of the 1st joint serrate.

Uropods: peduncles of the 1st a little longer than the rami, a few small spines on the inner side; rami equal, without spines or setæ; peduncles of the 2nd shorter than the equal rami, 2 or 3 small spines on the inner margins; peduncles of the 3rd about two-thirds the length of the outer ramus, with 2 short spines on the inner margin near the end, inner ramus slightly shorter than the outer, both with a few long setæ on the inner margins.

Telson cleft nearly to the base, with a terminal spine in an unequal-sided notch on each division.

Length 6 mm.

Very near *C. crenatipalmatus*, Steb., but differs in the shape of the hand of the 1st gnathopod, the armature of the telson and uropods, and the less upturned and blunter angle of the 3rd metasome-segment.

Named after Nicolai Hanson, the Naturalist of the 'Southern Cross' Expedition, who succumbed to the terrible rigors of the climate in Oct. 1899.

Genus Orchomenopsis, *G. O. Sars,* 1895.

Except as to the telson.

O. nodimanus *, n. sp.   (Pl. 7. figs. 13–17.)

Cape Adare, Nov. 4 & 5.   26 fath.   Many specimens.

Body slightly compressed ; segments of the mesosome subequal. First 4 side-plates about twice as deep as the segments, expanded downwards, the 1st produced in front beyond the head, finely granulate and pitted.   Metasome with a dorsal carina on the posterior half of each segment : hind and lower margins of the 3rd segment almost straight, the former smooth ; posterior angle obtuse but well defined.

Urosome hardly so long as the last segment of the metasome ; 1st segment carinate, 2nd very short.

Head almost concealed by the 1st segment and side-plate, lateral angle prominent, rounded.   Eyes large, dark, reniform, expanded below.

Upper antennæ : peduncle reaching to the end of the penultimate (2nd) joint of the peduncle of the lower antennæ, 1st joint more than twice as long as the next two ; flagellum 16-jointed, rather longer than the peduncle, the 1st joint about as long as the next seven : the accessory appendage 7-jointed, the 1st as long as the next three.

Lower antennæ : the last three joints of the peduncle subequal, reaching the middle of the flagellum of the upper antennæ.

Maxillipedes : outer plate with two curved spines on the outer side of the tip ; inner plate with three blunt spines at the tip.

First gnathopods very robust, the 1st joint expanded distally and posteriorly, the 2nd also much stouter and longer than the 3rd and 4th, concave above, convex and setose beneath ; carpus very short and produced behind to an irregular conical projection. Propodos narrowing distally, the hind margin about two-thirds the length of the front, concave, setose, *with a nodiform tubercle about the middle* ; the palm rectangular, with a cleft in the middle ; the dactylus projecting beyond the palm.

Second gnathopods normal.

Peræopods : 1st and 2nd robust, 3rd joint broad with parallel

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* From *nodus,* a knot, in allusion to the tubercle on the propodos of the first gnathopods.

margins, as long as the 5th and twice as long as the 4th joint, the 2nd, 3rd, and 4th joints setose, the 5th spinous on the hind margins.   The last three pairs increasing slightly in length successively, similar in form ; the 1st joint much expanded, the upper margin straight, the hind margin slightly serrate in the middle ; remaining joints spinous.   The side-plate of the 3rd pair about as wide as deep.

Uropods extending equally behind ; peduncles of the 1st pair twice as long as the equal rami; those of the 2nd pair about one-fourth longer than the subequal rami ; third pair lanceolate, peduncles two-thirds the length of the rami ; outer ramus one-fourth longer than inner, both spinous on the outer, setose on the inner margin.

Telson reaching considerably beyond the end of the peduncle of the third uropods, widely cleft for three-fourths of its length, with submarginal spines along the outer and inner margins, and two spines at the tip of each division.

Length 16 mm.

O. Rossi *, n. sp.   (Pl. 7. figs. 18–23.)

Lat. 78° 35′ S.; Feb. 18, 1900 ; near surface.   Many specimens.

Body slightly compressed.   *First 4 side-plates about as deep as the segments*, the 1st expanded in front, the rest very slightly expanded below, subrectangular.   Second segment of the mesosome shorter than the rest, which are subequal.   Third segment of the metasome with the hind margin almost straight, smooth, *posterior angle subacute*, lower margin convex.   First segment of the urosome with a dorsal depression.

Head as long as the 2nd segment ; *lateral angle rounded*. Eyes large, black, long-oval, expanded below.

Upper antennæ little longer than the head : 1st joint almost as broad as long, 2nd very short, 3rd rather longer than the 2nd. Flagellum 13-jointed ; 1st joint as long as the next five, with the usual long setæ and rows of setules ; accessory appendage 6-jointed, the 1st as long as the next four.

Lower antennæ : first and third joints subequal, the 2nd rather longer.

First gnathopods : first joint strong, rather longer than the next three.   Carpus short and produced behind beyond the base of the propodos, setose ; propodos truncate, contracted below

* After the well-known Antarctic navigator.

the palm; dactylus reaching a little beyond the strong spine at the palmar angle. Side-plates expanded and rounded in front.

Second gnathopods normal.

Peræopods: first and second with a few setæ on the hind margin of the 2nd, 3rd, and 4th joints and about 11 small spines on that of the 5th joint. Side-plates of the 3rd pair about half as large again as the 1st joint; this, in the last three pairs is expanded, slightly serrate on the hind margin, and produced downwards to the 3rd joint, which is much dilated behind; the spines few and short.

Uropods: first and second pairs with rami a little shorter than the peduncles, subequal, sparingly spinous; rami of the 3rd pair lanceolate, subequal, longer than the peduncle, almost spineless, with four or five setæ near the base the inner margin of the inner ramus; margins minutely serrate.

Telson reaching to about one-third the length of the rami of the 3rd uropods, cleft for two-thirds of its length, with three or four very small submarginal and one apical spine on each division.

Length 25 mm.

This large species appears to be nearly related to *Orchomenopsis obtusa*, G. O. Sars, from which it differs in its smaller side-plates and distinctly angulated 3rd metasome-segment.

Genus ORCHOMENELLA, *G. O. Sars*, 1895.

O. PINGUIDES, n. sp. (Pl. 8. figs. 24–30.)

Cape Adare, Nov. 4 & 5, 1899. Many specimens.

Body stout: 1st segment of the mesosome longer than the 2nd and about equal to the remaining segments. First 4 side-plates about twice as deep as the segments, the 1st narrowed, the two next widened below. *Third segment of the metasome produced behind in a smooth-edged subquadrate lobe with rounded angles.* First segment of the urosome with a dorsal carina.

Head about half as long as the 1st segment: *lateral angle produced, slightly rounded at the tip.* Eyes moderately large, dark, oval, expanded below.

Upper antennæ: 1st joint very stout and twice as long as the next two united; flagellum as long as the peduncle, the 1st joint about three-fourths as long as the remaining fourteen; the accessory appendage 5-jointed, the 1st longer than the rest united.

Lower antennæ a little longer than the upper, the 2nd joint of the peduncle the longest.

Maxillipedes : the outer plate reaching to the middle of the 3rd joint of the palp, and having apparently a double edge ; inner plate toothed at the apex, the innermost tooth the largest.

First gnathopods : 1st joint almost as long as the remaining joints. Front margin of the carpus $1\frac{1}{14}$ths of the same in the propodos ; this has parallel margins and is rectangularly truncate ; dactylus short, strong, and curved. Side-plates tapering and rounded distally.

Second gnathopod with the posterior margin of the propodos acutely produced ; side-plates subrectangular, rather the widest near the middle.

First and second peræopods longer than the rest. Third pair short, the 1st joint greatly expanded behind, the 3rd joint expanded and produced downwards : the side-plate more than twice as large as the 1st joint, deeper than wide. Fourth and fifth pairs with the 1st joint less expanded and subequal in length. The 1st joint in the last three pairs is indistinctly crenulate ; the 2nd and 3rd joints have a few long setæ and short spines on the front margin.

Third uropods have the peduncle slightly longer than the outer ramus, which is longer than the inner by the terminal nail. The outer ramus has 6 or 7 long setæ on the inner side ; the inner has several slighter setæ on the inner, and 2 or 3 spines on the distal half of the outer side.

Telson as long as the peduncle of the 3rd uropods, concave above, and divided rather more than one-third of its length ; a small spine at the tip of each division.

Length 7 mm.

Very near *Orchomenella pinguis* (Boeck) from the Siberian Polar Sea (Stuxberg).

O. FRANKLINI, n. sp. (Pl. **8**. figs. 31–36.)

Franklin Island, 10–24 fath., Feb. 9, 1900. One female.

Body very tumid. First three segments severally rather shorter than the next four. First 4 side-plates much deeper than the segments. Posterior angle of the 3rd *metasome-segment bluntly rectangular ; the hind and lower margins almost straight*. Urosome rather longer than the 3rd metasome-segment, the 1st segment *without carina or depression,* and longer than the next

two segments; the 2nd shorter than the 3rd. Head rather longer than the 1st segment; lateral angle acute. Eyes oval, dark.

Upper antennæ: the 1st joint three times as long as the next two, the peduncle naked except for a few scattered hairs. Flagellum about as long as the peduncle, 9-jointed, with a few long-jointed setæ; *the 1st joint entirely naked,* as long as the 3rd and longer than the 2nd joint. Accessory appendage 4-jointed, the 1st joint as long as the 3rd and longer than the 2nd.

Lower antennæ a little longer than the upper, the peduncle nearly twice as long as the 8-jointed flagellum, the first two joints subequal and each nearly twice as long as the last; the whole very sparsely setose.

First gnathopods: the 1st joint as long as all the rest; carpus two-thirds the length of the rectangular propodos; posterior margins of the 3rd, 4th, and 5th joints pilose, the rest of the limb sparsely setose. Side-plates expanded below.

Second gnathopods normal.

First and second peræopods with the 1st joint as long as the next three; dactylus about one-third the length of the 5th joint.

Third peræopods: the 1st joint widening out gradually from the base to a cycloidal lobe, about as broad as long, the hind margin scarcely serrate; the side-plates more than twice as large as the 1st joint, deeper than wide.

Fourth and fifth peræopods: the 1st joint deeper than wide, scarcely serrate.

Uropods: the 1st extending beyond the 2nd and these beyond the 3rd; the first two pairs almost naked, with the outer ramus longer than the inner. The 3rd pair have the peduncle longer than the inner ramus, which is quite smooth; the outer has one or two spines on the inner margin.

Telson concave above, pointed and divided to about one-third of its length.

Incubatory lamellæ very narrow. Branchial vesicles pyriform.

Length 6 mm.

Near *O. minuta* (Kröyer), but differs in the form of the urosome and telson, and in the small and naked 1st joint of the flagellum of the upper antennæ.

Genus TRYPHOSA, *Boeck*, 1870.

T. ADAREI, n. sp. (Pl. **8.** figs. 38–44.)

Cape Adare, Nov. 4 & 5, 1899. 26 fath.

Body moderately compressed. Segments of mesosome increasing in length successively. First 4 side-plates deeper than their segments ; 5th side-plate wider than deep. *Posterior angle of the 3rd metasome-segment obtuse, the hind margin convex, smooth, lower margin straight*. First segment of urosome with a dorsal depression.

Head as long as the 1st segment ; *lateral angle subacute*. Eyes generally not discernible, probably red, reniform.

Mouth-organs normal.

Upper antennæ : 1st joint of the peduncle stout, as long as the other two joints and 1st joint of flagellum ; 2nd and 3rd joints very short. Flagellum with 13 joints in the female, 24 joints in the male. Accessory appendage 6–7-jointed, reaching beyond the 5th joint of the flagellum, the 1st joint longer than the next two.

Lower antennæ : 1st joint short and thick, 2nd about the same thickness and twice as long, the 3rd more slender and one-third longer than the 2nd ; flagellum with 21 joints in the female, 31 in the male.

First gnathopods : side-plates narrowed and rounded below, with a small tooth at the distal end of the hind margin. First joint considerably longer than the next three ; anterior margin of the carpus almost as long as that of the propodos, which has the proximal half of the posterior margin somewhat dilated and furred ; palm oblique, setose, with very strong defining spines and a smaller spine placed obliquely at the base of the dactylus ; this is strong, with a secondary tooth.

Second gnathopods : propodos five-sixths the length of the hind margin of the carpus ; dactylus distinct. Side-plates oblong, widening downwards, with a small tooth at the hinder angle, not shown in the figure.

First and second peræopods : side-plates somewhat dilated below, the front margin rounded, the hind margin with a small tooth and setule ; 4th and 5th joints spinous on the hind margin.

Third peræopods : side-plates as wide but not as deep as the 1st joint, which is almost as wide as deep, narrowing below and much longer than the next three joints.

Fourth peræopods longer and stronger than the 3rd and 5th, the 1st joint oblong.

Fifth peræopods : the 1st joint oblong and longer than the rest of the limb.

All the last three pairs of peræopods have the hind margin of the 1st joint rather deeply serrate, the front margin of all the joints spinous, and the dactyli one-third the length of the 5th joint, slightly curved.

Uropods subequal in extent, the 1st and 2nd with the peduncles and rami subequal and spinous ; the peduncle of the 3rd shorter than the rami, with a few strong spines at the distal end ; rami spinous, the inner slightly shorter than the outer.

Telson longer than the peduncle of the 3rd uropods ; cleft almost to its base, with 4 or 5 submarginal and a terminal spine on each division.

Length 20 mm.

This species much resembles *T. antennipotens*, Stebbing, and *T. barbatipes*, Stebbing, but differs from both in its shorter first joint and longer accessory appendage of the flagellum of the upper antennæ, in the shape and relative proportions of the hand and wrist of the 1st gnathopods, &c. It is also very near *T. angulata*, G. O. Sars, but differs in the shape of the lateral angle of the head.

TRYPHOSA MURRAYI *, n. sp. (Pl. 9. figs. 45–51.)

One male specimen. Tube A. 39. No locality given.

Body moderately compressed. First 4 side-plates at least twice as deep as the segments. Third segment of metasome with the hind margin almost straight, the lower margin slightly convex ; posterior angle subrectangular. First segment of the urosome with a prominent triangular carina.

Head : lateral angles produced and subacute. Eyes obsolete.

Mouth-organs normal. Epistomal plate prominent, evenly rounded.

Upper antennæ : 1st joint stout and twice as long as the 2nd and 3rd united. Flagellum 23-jointed, the first as long as the next four, with a double row of setiferous ridges ; the 5th very short. Accessory appendage 6-jointed, reaching a little beyond the 5th joint of the flagellum, the 1st joint about as long as the next three.

Lower antennæ : second joint of the peduncle longer and stouter than the last. Flagellum with about 30 joints.

First gnathopods : the 1st joint as long as the 3rd, 4th, and 5th ; the carpus about as long as the propodos, which is somewhat

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* Named in honour of my friend Mr. G. Murray, F.R.S.

expanded at the proximal end; palm oblique. Side-plates narrowing downwards, with a small tooth at the posterior angle.

Second gnathopods: the propodos fully as wide as the carpus, upper and lower margins subparallel, the latter not produced. Side-plates slightly expanded below, with a small tooth at the posterior angle, not shown in the figure.

First and second peræopods rather slender, the 5th joint spinous on the anterior margin.

Third peræopods: the 1st joint wide but narrower than the side-plate and about as deep; the 3rd joint considerably expanded behind; the 4th joint wider than the 5th, and also than the 4th joint in the last pair of peræopods.

Fourth and fifth peræopods: the 1st joint larger than in the 3rd peræopods: the 3rd joint less expanded; the 1st joint in the last three pair of legs is serrate behind, and all the joints are more or less spinous.

Uropods: the 1st pair extend beyond the 2nd, the inner ramus shorter than the outer: the rami of the 2nd and 3rd pairs are subequal, in the last both rami are spinous and setose on the inner margin, and the outer has two large spines on its outer margin, the inner a little the shorter.

Telson long, cleft almost to its base, with 3 or 4 spines on each margin and the usual single apical spine.

Length about 15 mm.

T. Murrayi belongs to a group of northern species with the hind margin of the 3rd metasome-segment almost or quite straight, and with a triangular carina on the 1st urosome-segment. Of these, *T. Höringii*, Boeck, and *T. angulata*, G. O. Sars, differ in the form of the lateral angle of the head; while *T. compressa*, G. O. Sars, differs in the much compressed body, in the form of the propodos of the 2nd gnathopod, and the relative proportions of this and the 1st gnathopod.

Genus HOPLONYX, *G. O. Sars*, 1895.

H. KERGUELENI (*Miers*).

Lysianassa Kergueleni, Miers, Ann. & Mag. Nat. Hist. ser. 4, xvi. 1875 p. 74.

Anonyx Kergueleni, Miers, Zoology of Kerguelen Island, 1879.

Hippomedon Kergueleni (Miers), Stebbing, ' Challenger ' Amphipoda.

Duke of York Island, Oct. 1899; 6 fath.   Cape Adare, Nov. 1899; 26 fath.

The most abundant species in the collection.   The largest specimen measured 20 mm.

HOPLONYX STEBBINGI, n. sp.   (Pl. **9**. figs. 52–57*.)

Cape Adare, Nov. 4 & 5, 1899; 26 fath.   Several specimens.

Body moderately compressed.   *Third segment of the metasome with the posterior angle recurved, but less so than in H. Kergueleni.*   First segment of the urosome neither dorsally depressed nor carinate.

Head rather shorter than the 1st segment.   *Lateral angle produced to the end of the 1st joint of the upper antennæ, the point rounded.*   Eyes not seen.

Mouth-organs normal.

Upper antennæ : first joint almost as broad as long ; next two very short.   Flagellum 15-jointed, the 1st rather longer than the next three, the 2nd very short.   Accessory appendage 6-jointed, the 1st as long as the next two, the 6th minute.

Lower antennæ : second joint of peduncle almost as long as the 1st and 3rd together.   Flagellum 17-jointed.

First gnathopods : first joint about as long as the next three ; carpus as long and, in its distal portion, as wide as the propodos ; sides of the latter parallel.   Dactylus deeply divided.   Side-plates narrowed and rounded below.

Second gnathopods of the usual form, with dense tufts of setæ on the 3rd, 4th, and 5th joints.   Length of propodos to width as 5 : 3.

First peræopods : 1st and 3rd joints about equally long, with subparallel margins ; 3rd and 4th with a few fascicles of setæ, and the 5th with about six spines on the hind margin.

The last three pairs of peræopods have the 1st joint almost as long as the remaining joints, the hind margin expanded and slightly serrate.   The 3rd pair is rather shorter, and has the 3rd joint more expanded than the 4th and 5th pair.

First and second uropods have the peduncles rather longer than the subequal rami and are sparsely spinous.   The peduncle of the 3rd uropods is shorter than the rami, of which the outer is slightly the longer ; both rami are sparsely setose on the inner margin.

Telson long and narrow, cleft almost to the base.

Length 18 mm.

Differs from *H. Kergueleni* in the absence of a depression on the 1st urosome-segment, the less upturned angle of the 3rd metasome-segment, the blunt lateral angle of the head, the narrowed side-plates of the 1st gnathopods, &c.

Genus AMPELISCA, *Kröyer*, 1842.

A. MACROCEPHALA, *Lilljeborg*. (Pl. **9.** figs. 58–61*.)

One female with ova. Tube " A."

With the exception of the hind margin of the 3rd segment of the metasome, which is rather less convex, and the lower margin of the 1st joint of the last peræopods, which is less truncate than in Northern specimens, the present example agrees with Lilljeborg's species, even to the peculiar spine on the outer ramus of the 2nd uropods. This species is widely distributed in the Arctic seas, and occurs in the British seas.

Genus OEDICEROS, *Kröyer*, 1842.

O. NEWNESI *, n. sp. (Pl. **9.** figs. 62–66, Pl. **10.** figs. 67, 68.)

Cape Adare, beach, April 5 & 15, 1899. Two specimens.

Female with ova.

Body compressed. First four side-plates almost as deep as the segments. First three segments shorter than those succeeding, raised at the hind margin. Third segment of the metasome rounded behind.

Head as long as the first two segments; rostrum strongly deflexed, pointed, and reaching nearly to the end of the 1st joint of the upper antennæ; lateral angles rounded. Eyes dark. Mouth-organs normal.

Upper antennæ reaching a little beyond the 2nd joint of the lower, 1st joint about as long but twice as thick as the 2nd, 3rd joint about one-third as long as the 2nd. Flagellum 10-jointed.

Lower antennæ imperfect.

First gnathopods: first joint barely as long as the carpus and propodos, with long setæ on the upper and lower portions; carpus about two-thirds the length of the propodos, produced behind into a rounded setose lobe; propodos oval, the palm, which is slightly contracted at the proximal end, about twice as long as the rest of the hind margin. Dactylus slender. Side-plates expanded below and fringed.

Second gnathopods: *first joint longer than the rest of the limb*; carpus more produced than in the first gnathopods; *palm of propodos shorter than the rest of the hind margin.* Side-plates rounded, oblong, fringed with more or less plumose setæ.

* Named in honour of Sir George Newnes, Bart., M.P., who provided the funds for the expedition of the 'Southern Cross.'

First and second peræopods : fourth joint about as long but twice as thick as the 5th, densely clothed with long setæ on the posterior margin ; the 5th joint similarly clothed on the anterior margin. Dactylus acutely ovate.

Remaining parts as in *O. saginatus*, Kröyer.

Length 8 mm.

Very near *O. saginatus*, from which it differs principally in the more compressed body, and in the longer and narrower form of the 2nd gnathopod.

Fam. EPIMERIDÆ.

Genus EPIMERIA, *Costa*, 1851.

E. INERMIS *, n. sp. (Pl. **10**. fig. 69.)

Cape Adare, 28 fath. One specimen.

Body robust ; 1st segment a little longer than the 2nd, but shorter than the 3rd, remaining segments of mesosome longer, with elevated dorsal carinæ. First three side-plates narrow, pointed, angularly convex, and about as deep as the segments. Fourth side-plate broad, *the lower margin obtusely angulated*, and forming an acute angle with the hind margin. The 5th and 6th side-plates quadrangular and convex, the posterior angle subacute, *not produced* ; the 7th small, rounded, and partly concealed by the downward prolongation of the segment. The lower part of the mesosome-segments is slightly raised, forming a low tubercle.

The 1st segment of the metasome is narrowed and rounded below ; the 2nd and 3rd segments have the posterior angle acute, the hind margin in the last being convex ; the dorsal carina on the 2nd segment has a shallow median notch ; the carina of the 3rd segment is lower with an irregular margin.

The 1st segment of the urosome is dorsally depressed, scarcely carinate ; the 2nd segment very short, the hind margin elevated ; the sides of the last segment are elevated behind.

The telson is rather more tapering than is usual in this genus, with a small terminal notch.

The rostrum is about as long as the rest of the head ; the eye as in *E. cornigera* (Fabr.) and other species.

Length 28 mm. Colour red.

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* " Unarmed," from the absence of the blade-like prolongations of the 4th and 5th side-plates that are found in the other species of the genus.

As the important characters in this genus are external, and as it was desirable not to mutilate the single fine specimen, I have not attempted to describe the mouth-organs or limbs, the latter of which appear to resemble those of *E. cornigera* (Fabr.). The absence of the acute prolongations of the 4th and 5th side-plates distinguishes it from the Northern species.

Fam. EUSIRIDÆ.

Genus EUSIRUS, *Kröyer*, 1845.

E. LÆVIS *, n. sp.   (Pl. **10**. figs. 70–76.)

One specimen ; no locality given.

Body compressed, *without dorsal teeth or posterior projections. Third segment of metasome with the posterior margin rounded and smooth.*

Head as long as the first two segments, with a short rostrum. Eyes rather small and round.

Maxillipedes with the dactylus largely developed.

Upper antennæ nearly twice as long as the lower ; first two joints subequal, the 3rd shorter than the 1st joint of the flagellum, the distal margin somewhat dentate ; secondary appendage about three-fourths the length of the 1st joint of the flagellum. Flagellum 11-jointed, the 1st and 10th joints the longest.

Lower antennæ: peduncle reaching beyond the middle of the 2nd joint of the upper antennæ.   Flagellum 5-jointed.

Gnathopods of the usual structure in this genus ; the propodos much wider than long ; carpal projection shorter than usual ; the 1st joint of the 1st gnathopods much wider than that of the 2nd pair, otherwise they are alike.

First and second peræopods about as long as the gnathopods, slender, without spines, and with only a few setules ; dactyli strong.

First joints of the last three pairs of peræopods moderately wide *with smooth margins.*

Telson reaching to the end of the peduncle of the 3rd uropods. Length 4 mm.

This species may be easily distinguished from the other known species by the absence of dorsal teeth on the segments and by the entire margins of the 3rd metasome-segment and the 1st

* *Lævis*, smooth, from the absence of dorsal prolongations and of teeth on the margins of the 3rd metasome-segment and 1st joints of peræopods.

joints of the peræopods. From *E. cuspidatus*, var. *antarcticus*, Thomson, it is separated by the conspicuous dactylus of the maxillipedes.

Fam. CALLIOPIIDÆ.

Genus nov. ORADAREA *.

Body compressed.

Third joint of mandibular palp rather shorter and narrower than the 2nd.

Maxilla and maxillipedes as in *Amphithopsis*, G. O. Sars.

Upper antennæ with a small secondary appendage.

Lower antennæ considerably longer than the upper.

Gnathopods very unequal, the 2nd much longer and proportionately narrower than the 1st.

Telson entire.

This genus is very near to *Amphithopsis*, Boeck, 1870, as restricted by G. O. Sars (' Amphipoda of Norway,' p. 455), but differs in the more compressed body, the narrow 3rd joint of the mandibular palp, and the relative inequality of the gnathopods and antennæ. From Boeck's definition it also differs in the dorsal prolongation of the first two segments of the metasome (Boeck says " *Corpus compressum, nec carinatum, nec spinosum* "). The greater length of the lower antennæ than the upper justifies the placing of this genus in the Calliopiidæ even more than *Amphithopsis*, but, as G. O. Sars remarks of the latter, both show considerable affinity with the Paramphithoidæ.

O. LONGIMANA, n. sp.   (Pl. **10.** figs. 77–89.)

Cape Adare beach, after gale, April 5, 1899 ; Jan. 17, 1900. Dredged, 8 fath., Jan. 17, 1900.

Body rather swollen. Segments of mesosome subequal, except the last which is as long as the two preceding.   First two segments of metasome in adults dorsally produced in a sharp tooth ; the 3rd segment has the hind margin straight, but hollowed out just above the acute posterior angle, lower margin convex. Urosome about as long as the last two segments of the metasome. Anterior side-plates of the mesosome slightly turned outwards, convex.

Head as long as the first two segments ; rostrum very short, acute. Eyes not discernible.

* From *Ora*=beach, and *Adare*.

Upper antennæ with the 1st joint twice as long and half as thick again as the 2nd, which bears the same proportion to the 3rd, this reaches to the end of the 2nd joint of the peduncle of the lower antennæ. Flagellum very long and slender. Accessory appendage one-third the length of the 1st joint of the flagellum, which is transversely striated and as long as the next three joints.

Lower antennæ longer than the upper; 1st joint less than half as long as the 2nd, which is rather shorter than the 3rd.

First gnathopods: side-plates rather small, oblong-oval, the lower part of the anterior margin slightly serrate. First joint rather longer than the next three; carpus rather shorter than the propodos; sides of the propodos almost parallel, the length being to the width as 3·5 to 1·5; the hind margins of the 3rd, 4th, and 5th joints are furnished with dense fascicles of setæ, which are plumose and generally forked at the tip.

Second gnathopods about twice as long as the 1st; the side-plates like those of the 1st; 1st joint a little longer than the propodos; carpus about three-fourths as long as the propodos, the length of which is to the width as 7 to 1·5, both these joints have the hind margins furnished with fascicles of setæ.

First and second peræopods: the 1st joint narrow and about as long as the 5th; dactylus strong, slightly curved and about one-third as long as the 5th joint.

Last three pairs of peræopods alike; the 1st joint broadly oval, slightly serrate on the hind margin, and about as long as the 4th joint; the 5th joint the longest; 3rd, 4th, and 5th joints spinous on both margins.

Uropods subequal in extent; outer ramus of 1st pair rather *more* than half as long as the inner; outer ramus of 2nd pair rather *less* than half as long as the inner; outer of 3rd pair *more* than half as long as the inner, which is wider than the rami of the first two pairs, lanceolate, and finely denticulate on the inner margin. All the uropods are sparsely spinous.

Telson reaching a little beyond the end of the peduncle of the 3rd uropods, concave above.

Length of female with ova, 9 mm.

This species affords a good illustration of the unsatisfactory nature of characters taken from modifications of the segmental margins. Along with the specimens as described above were taken a number of others, as a rule smaller, but some very nearly

as large as the egg-bearing females. These (and also the embryos from the female described above) had the posterior margin of the first two segments of the metasome simple, *i. e.* not produced into a dorsal tooth, and with a slight difference in the sculpture of the posterior margin of the 3rd segment. In other respects they are identical with the adult specimens, and there can be no doubt that these differences are only due to immaturity. The same thing is found in *Paramphithoë bicuspis* (Kröyer), the immature form having been made a distinct species (*P. monocuspis*, G. O. Sars). Canon A. M. Norman has called attention to the variability of the sculpturing of the posterior margins of the segments of the pleon (metasome and urosome) in *Melita obtusata* (Montagu) [Ann. & Mag. Nat. Hist. ser. 6, vol. iv. 1889, p. 132.]

Fam. ATYLIDÆ.

Genus ATYLOIDES, *Stebbing*, 1888.

A. SERRATICAUDA, *Stebbing*, Report on ' Challenger ' Amphipoda, p. 920, pl. 78. (Pl. **11**. fig. 90.)

Cape Adare beach, after gale, Jan. 25, 1900.

Many specimens of various ages.

Length 12 mm.

The above specimens differ from that described by Mr. Stebbing, which was taken off Melbourne in 33 fath., only in having seven teeth on the posterior margin of the 3rd metasome-segment instead of two. As I have pointed out under the species last described, this is not of sufficient importance to warrant the making of a new species.

Genus ATYLUS, *Leach*, 1817.

A. ANTARCTICUS, n. sp. (Pl. **11**. figs. 91–97.)

Cape Adare beach, April 5 & 15, 1899.

Many of various ages.

Body moderately compressed. First four side-plates not so deep as the segments, increasing in width successively. Last three segments of mesosome and first two segments of metasome with an elevated and acutely-angled dorsal carina; *carina of the 3rd segment of the metasome rounded posteriorly ; the hind margin of this segment forms a continuous curve with the lower margin and has four or five shallow teeth.* Urosome with a dorsal depression on the 1st segment.

Head about as long as the first two segments; rostrum about one-fourth the length of the 1st joint of the upper antennæ; lateral angle as in *A. carinatus* (Fabr.). Eyes rather large, oval, dark.

Mouth-organs as in *A. carinatus* (Fabr.) except the mandibular palp, the 3rd joint of which is rather shorter than the 2nd.

Upper antennæ about one-third longer and thicker than the lower, about two-thirds the length of the body; 1st joint of flagellum longer than the 2nd and 3rd, the 2nd more than twice as long as the 3rd. Flagellum about twice as long as the peduncle. Accessory appendage half as long as the 1st joint of the flagellum.

Lower antennæ: the peduncle reaches to the end of the 2nd joint of the upper; 1st joint one-third the length of the 2nd, which is rather longer than the 3rd.

Gnathopods almost alike, the first a trifle the smaller; they closely resemble those of *A. carinatus* (*vide* G. O. Sars, 'Amphipoda of Norway,' p. 471, pl. 166), except in being less setose, especially on the anterior margin of the propodos. Side-plates oblong, narrowing slightly below, with the angles rounded.

First and second peræopods longer and more slender than in *A. carinatus*, the 3rd joint very little expanded distally and almost as long as the 5th.

Third peræopods with the 1st joint oblong, narrowed below, the margins straight, rather longer than the 3rd joint, which is very slightly expanded distally; 3rd, 4th, and 5th joints subequal.

Fourth peræopods similar in form but rather longer than the 3rd; 1st joint oblong, the hind margin slightly concave. All three pairs have five pairs of spines on the anterior margin of the 5th joint. The 5th pair have the 1st joint rather wider, with the hind margin convex and serrate.

First and second uropods subequal in extent, the 3rd reaching a little beyond them. The outer rami are shorter than the inner, especially in the 2nd pair; the peduncles are longer than the rami in the 1st and 2nd and rather shorter in the 3rd, these have a few spines on both margins, but no setæ.

Telson reaching just beyond the end of the peduncles of the 3rd uropods, tapering distally, with a narrow cleft about one-third of its length; the ends of the divisions truncate, with a seta and setule a little before the end of each.

Length of female with ova 15 mm.

Very near *A. carinatus*, from which it differs in the carina and hind margin of the third metasome-segment, the length of the rostrum, size of eyes, 1st joint of the last peræopods, proportions and armature of 3rd uropods, form of telson, &c. It is nevertheless very remarkable that two forms—the one a strictly Arctic species—should be found at opposite poles, when not one other species of the genus, as restricted by G. O. Sars, has, so far as I know, been found elsewhere, unless, as suggested by G. O. Sars, *Atylus Huxleyanus*, Sp. Bate (*Halirages Huxleyanus* in the 'Challenger' Amphipoda), ought to be referred to it. From this species *A. antarcticus* differs considerably more than it does from *A. carinatus*.

Bovallia gigantea, Pfeffer, Krebse v. Süd-Georgia, is also nearly related to this species, from which it differs in the keels on the segments, which in *Atylus antarcticus* begin on the 5th and in *Bovallia* on the 6th segment; also in the form of the eye and telson, in the armature of the peduncle of the upper antennæ, and probably in other respects. The 3rd segment of the metasome is not described by Dr. Pfeffer.

Fam. GAMMARIDÆ.

Genus LILJEBORGIA, *Sp. Bate*, 1862.

L. HASWELLI, *Stebbing*, 'Challenger' Amphipoda, p. 985, pl. 92. *Eusirus dubius*, Haswell.

Four specimens.   Cape Adare, 26 fath., Dec. 1, 1899.

Length of largest 20 mm.

The specimens agree with Mr. Stebbing's description except as to the armature of the hind margin of the segments of the mesosome and metasome, which varies with the age of the individual. The 'Challenger' specimen was from Bass Straits.

Fam. PHOTIDÆ.

Genus HAPLOCHEIRA, *Haswell*, 1880.

H. PLUMOSA, *Stebbing*, 'Challenger' Amphipoda, p. 1172, pl. 126.

Cape Adare, Nov. 4 & 26, 1899 ; 26 fath.   Franklin Island, 10–24 fath., Feb. 9, 1900.

Several specimens.   Length 6 mm.

Fam. ISCHYROCERIDÆ, *Stebbing*.*

Genus JASSA †, *Leach*, 1815.

(Syn. *Podocerus*, auctorum.)

J. GONIAMERA ‡, n. sp. (Pl. **11**. figs. 98–106 *a*.)

Many specimens, Cape Adare, Nov. 10, 14, & 26, 1899 : 26 fath.

Body scarcely compressed. First four side-plates small, rounded below ; 5th smaller than the 4th, obtusely angled below. First segment the shortest, remaining segments subequal. Hind margin of 3rd metasome-segment convex, forming an obtuse angle with the lower margin.

Head almost as long as the first two segments. Eyes rather large, dark, prominent.

Upper antennæ reaching a little beyond the last joint of the peduncle of the lower, 2nd and 3rd joints subequal, 1st about half as long. Flagellum rather longer than the last joint of the peduncle, 14-jointed, the 1st joint as long as the next three. Accessory appendage 1-jointed, about one-third the length of the 1st joint of the flagellum. The whole rather sparingly clothed with long setæ on the underside.

Lower antennæ : the 1st joint barely half as long as the 2nd ; the 3rd one-third longer than the 2nd. Flagellum shorter than the 3rd joint, the 1st joint as long as the next three ; very sparsely clothed with short setæ.

Dactylus of palp of maxillipedes blunt at the tip, which is clothed with long setæ. Other mouth-organs normal.

First gnathopods as in *Jassa falcata* (Montagu).

Second gnathopods : first joint about half as long as the pro-podos. Carpus very short, cup-shaped, not produced behind. Propodos about three times as long as wide ; a strong tooth near the proximal end and another irregular one near the distal end of the posterior margin. Dactylus strong, reaching almost to the proximal tooth.

First peræopods : first joint almost as long as the remaining

* Ann. & Mag. Nat. Hist. ser. 7, vol. iv. 1899, p. 211.

† See G. O. Sars, 'Amphipoda of Norway,' under *Podocerus*, p. 593, for definition of genus, except as to 3rd uropods.

‡ From γωνία, angle, μηρός, thigh, alluding to the form of the 1st joint of the last peræopods.

joints ; the 3rd as long as the next three ; the 4th shorter than the 5th, which has tufts of setæ on both sides.

Third peræopods : first joint oblong, hind margin almost straight and scarcely produced downward, *posterior angle rounded* ; 3rd joint enlarged.

Fourth and fifth peræopods rather longer than the 3rd, *the posterior angle of the 1st joint produced downwards in a subacute angle.*

First and second uropods : peduncles longer than the rami ; inner rami longer than outer ; peduncles and rami spinous.

Third uropods reaching to the end of the shorter ramus of the 2nd uropods ; peduncle about four times as long as the inner ramus, with a close transverse row of small spines on the upper side and a group of larger spines at the inner angle at the distal end ; inner ramus almost straight, with a microscopic spine near the tip ; outer much curved and twisted, rough with minute denticles, and a minute excavation with a forked setule near the point, *but without secondary teeth.*

Telson very short, triangular, acuminate, a seta at each side of the point.

Length 20 mm. Colour in spirit olive-green.

The only difference I have observed between male and female in this species is that the propodos of the 2nd gnathopod is slightly smaller in the female. Even in the very young, under 3 mm. long, this limb has the same form and proportion to the body as in adults. The third uropods agree rather with those of *Janassa*, Boeck (*Parajassa*, Stebbing), while the antennæ resemble those of *Jassa*. Should it be thought desirable to form a new genus on this account, I suggest the name of *Hemijassa*, because of its intermediate character.
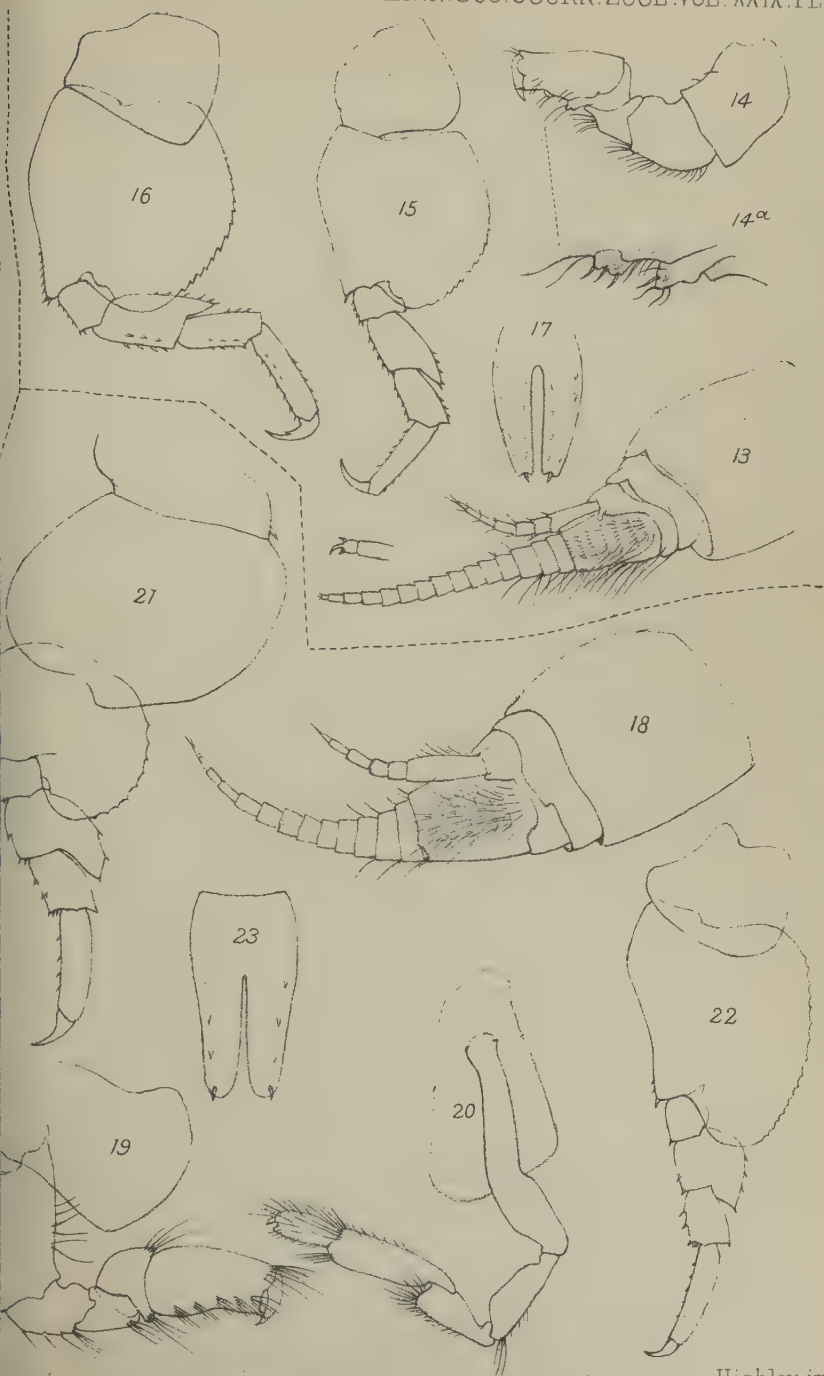
I have received from Mr. J. A. Clubb a specimen of this species found among the tentacles of a sea-anemone (*Urticina Carlgreni*, Clubb), described by him in the Brit. Mus. Report on the ' Southern Cross ' Collection, p. 299, and considered by him to be a commensal. I suggest that, as it appears to be an abundant species, the specimens so found may have been accidentally entangled in the tentacles while in the dredge.
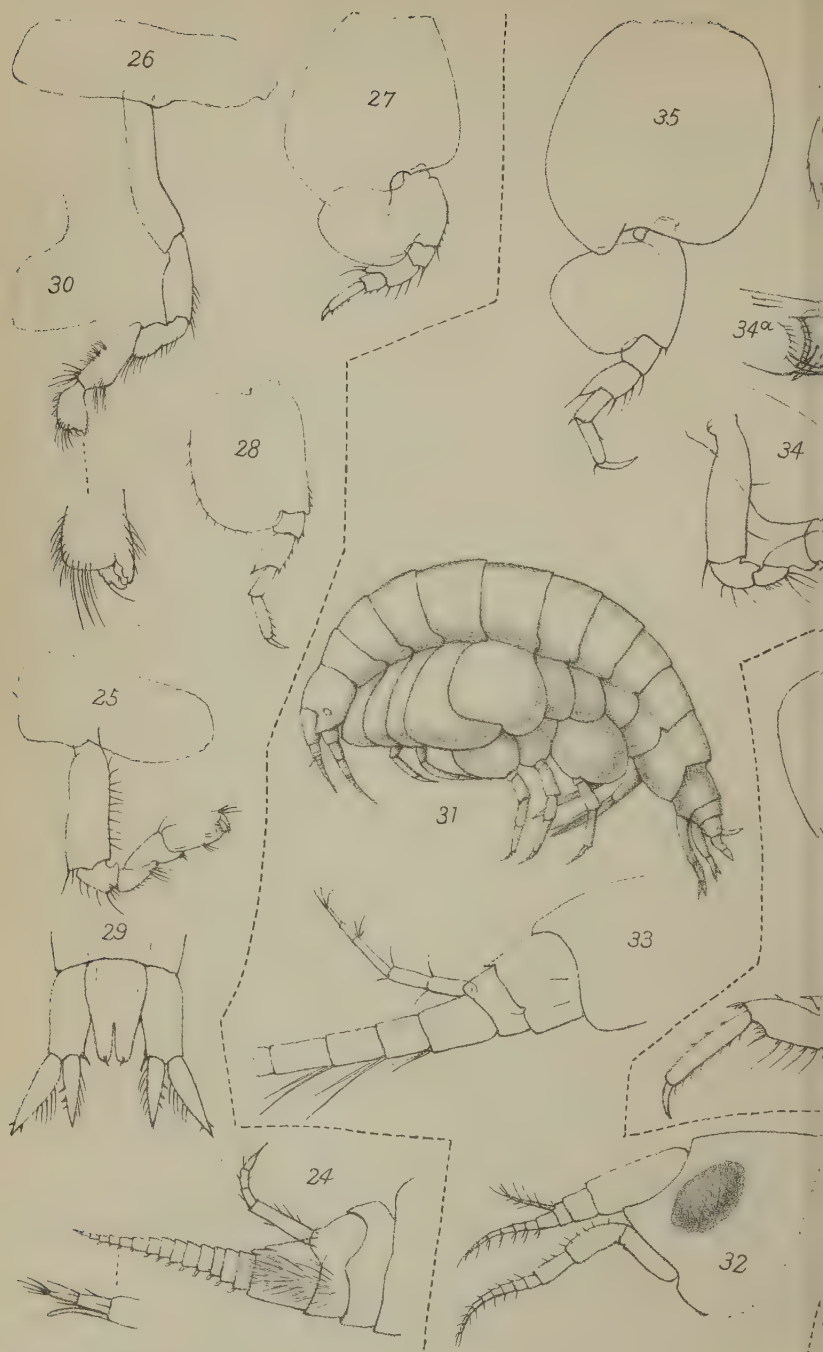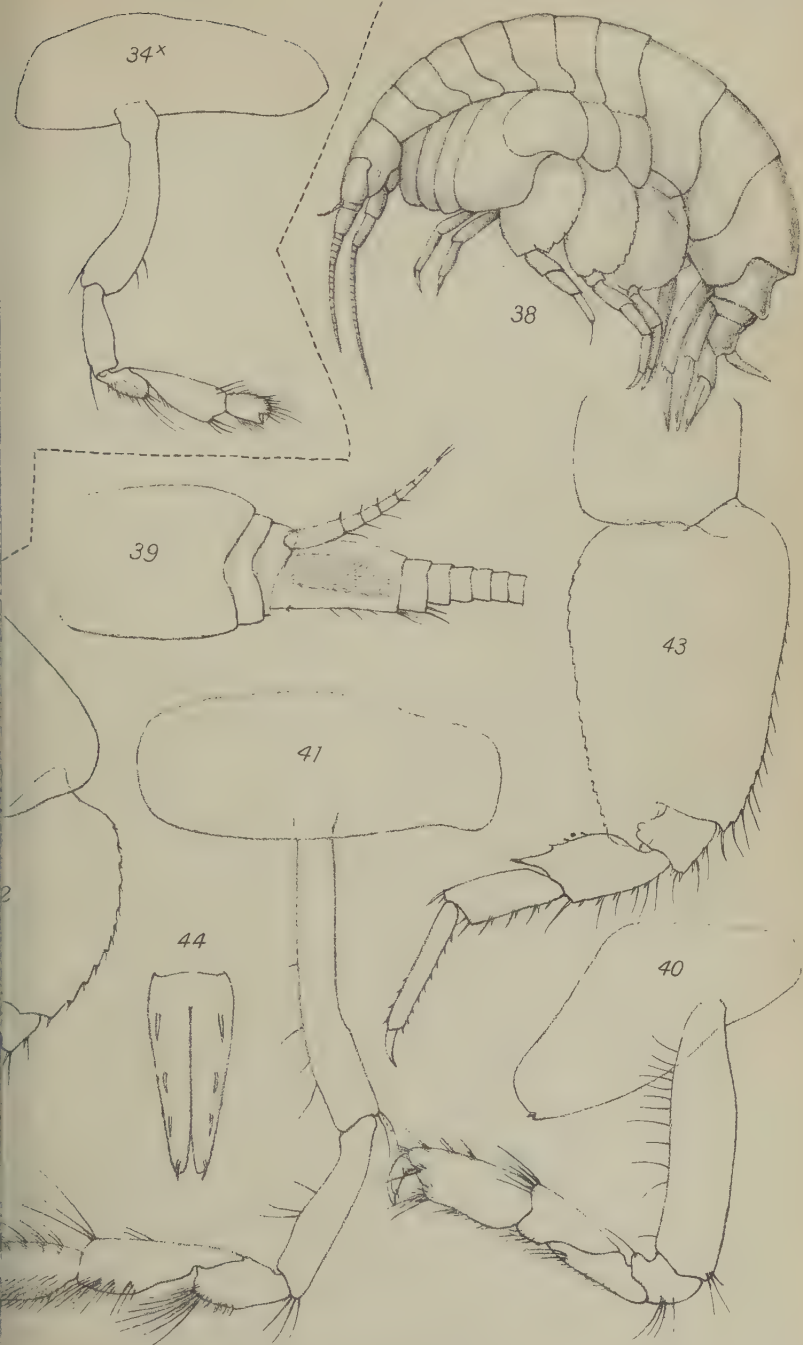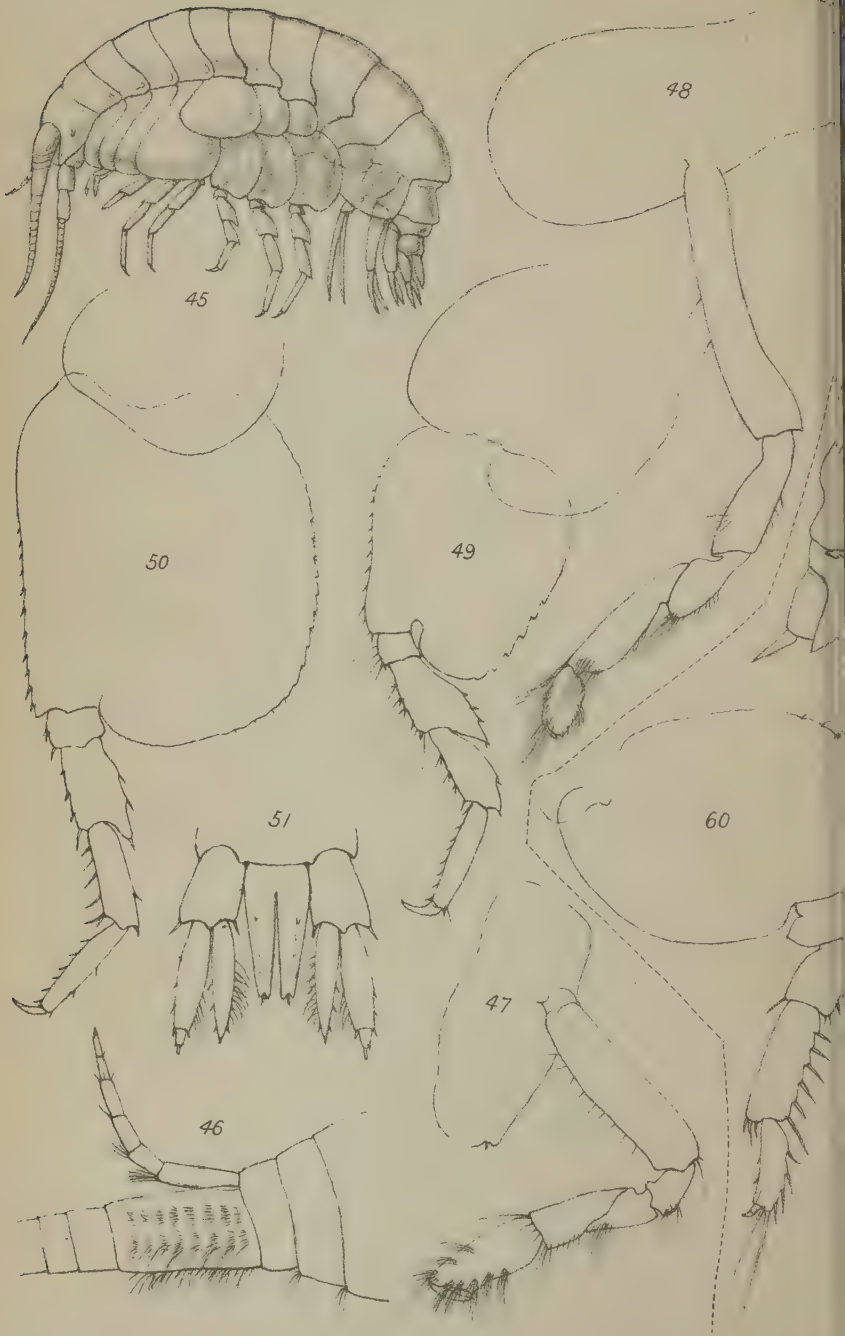
Walker.
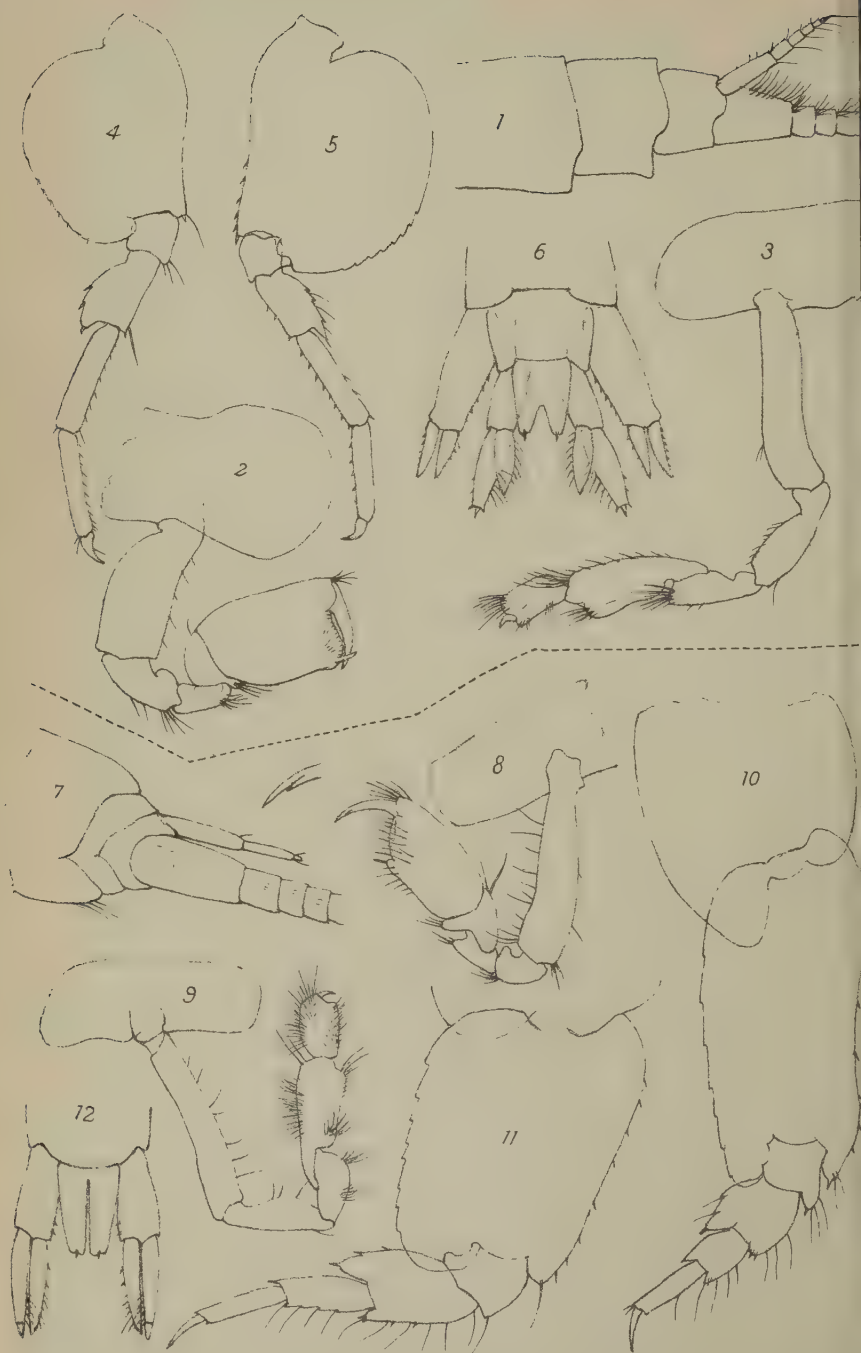
P. Highley del. et lith.

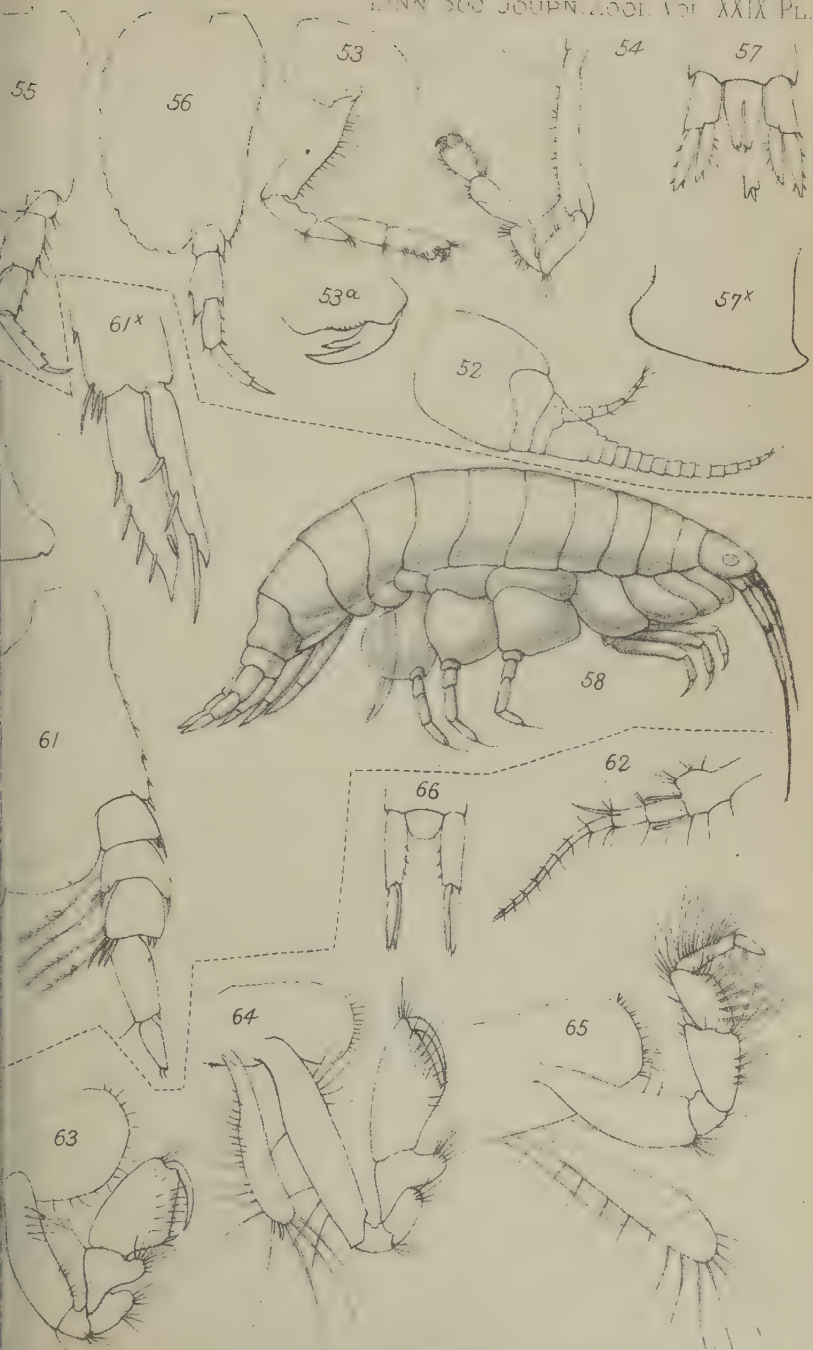Highley imp.

PHIPODA.

W

P I

PHIPODA .

P

HIPODA.

Walker.

68

67

75

89

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P. Highley del. et lith.

Highley imp.

98

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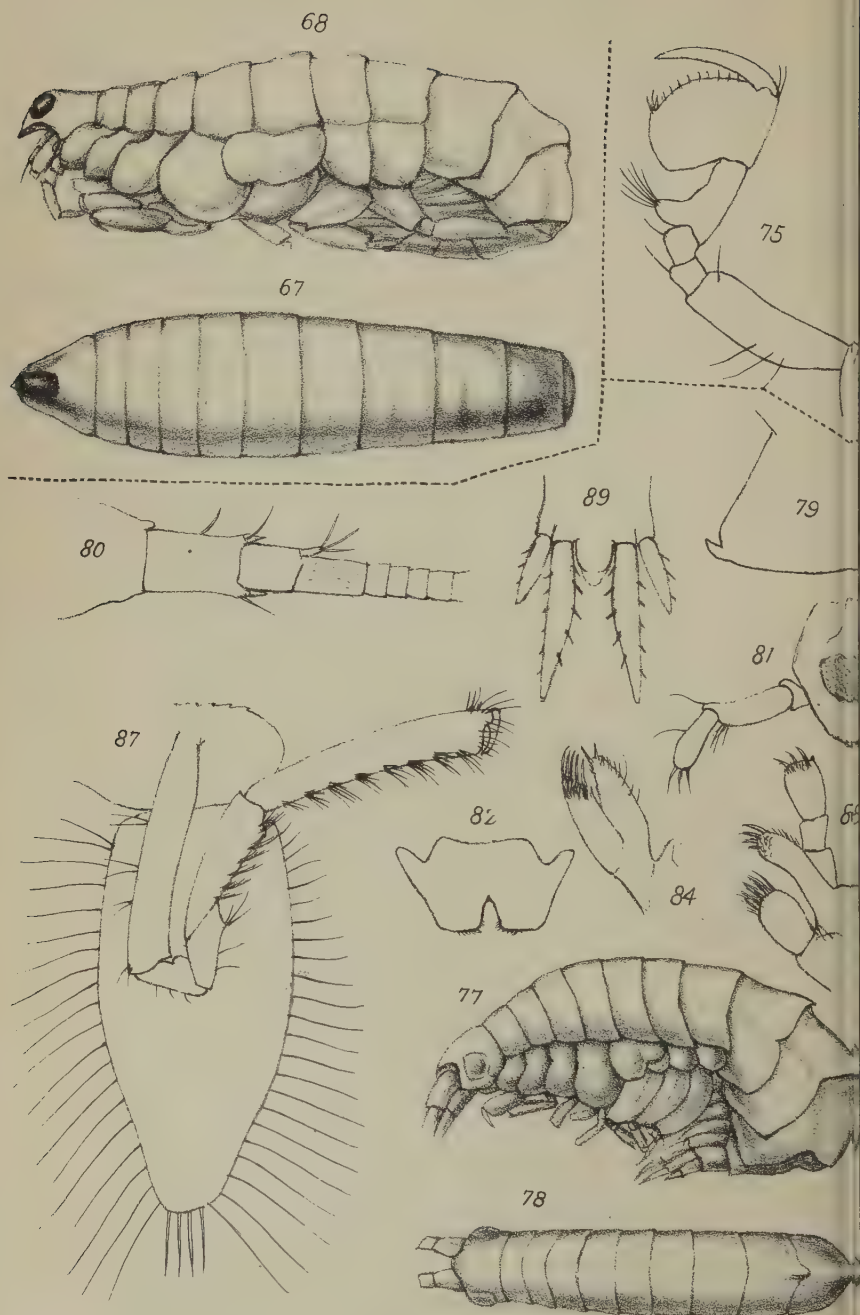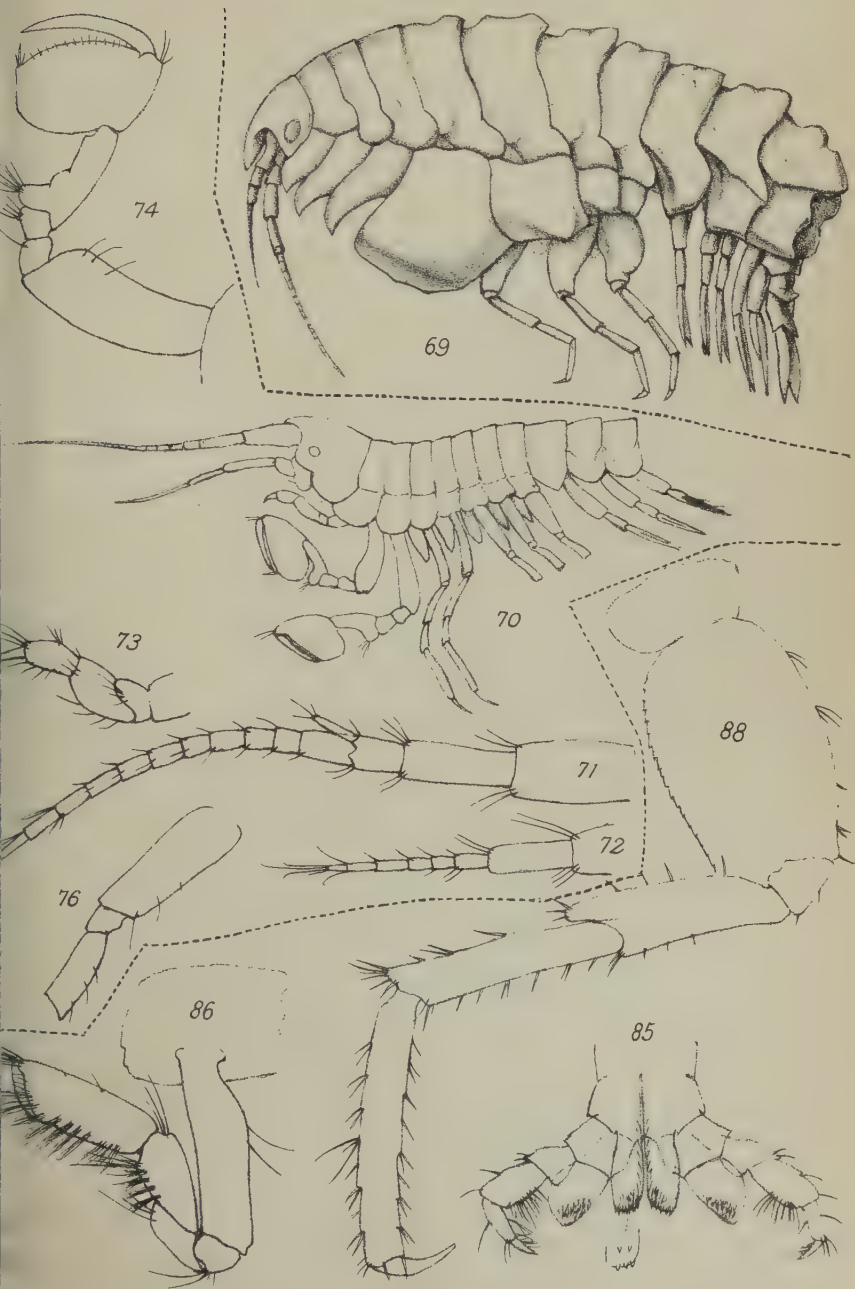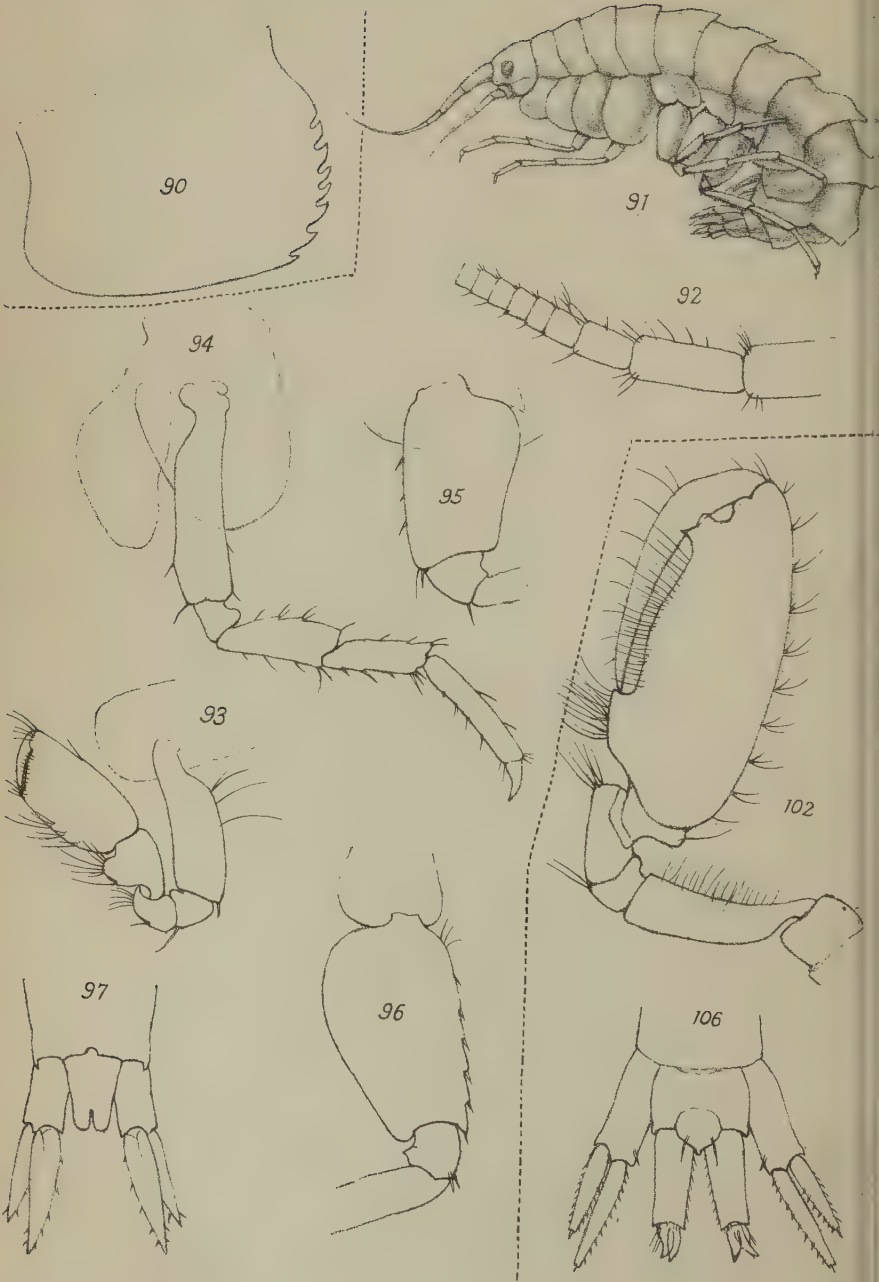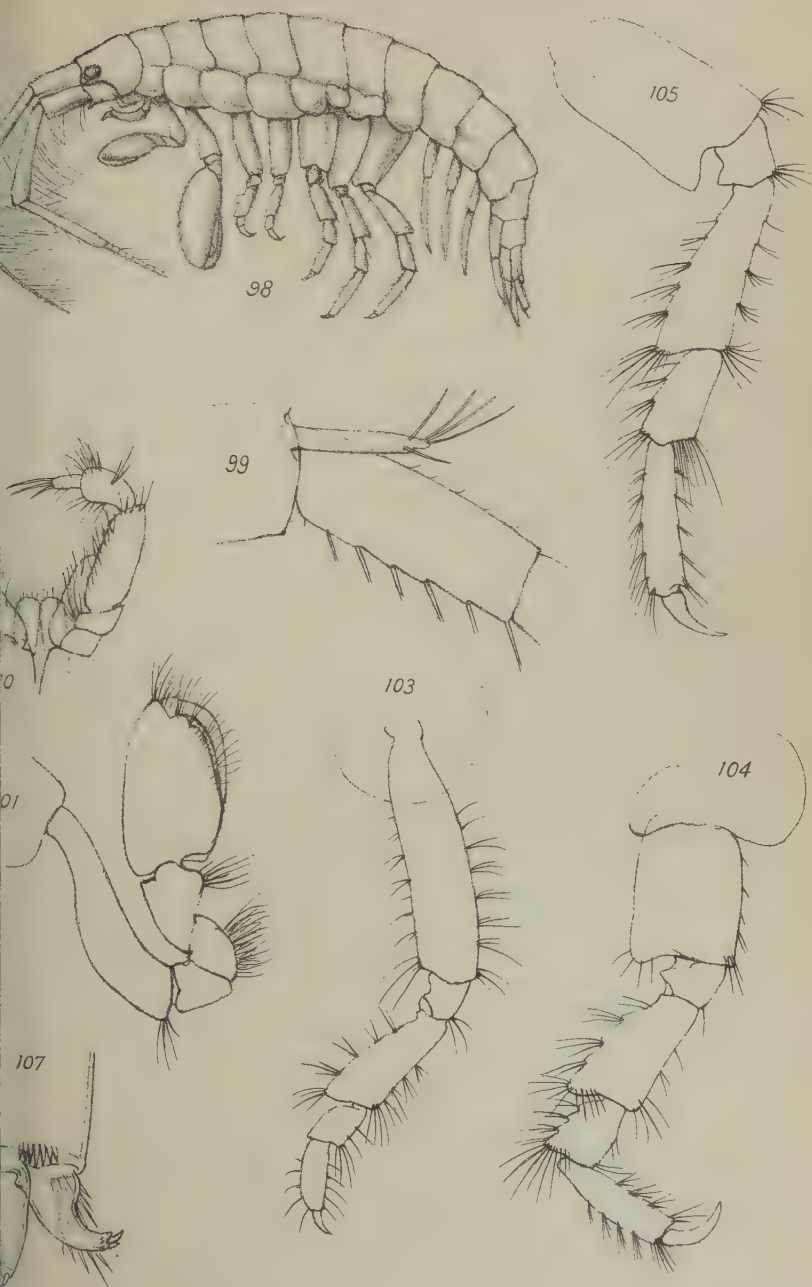
Highley imp.

EXPLANATION OF THE PLATES.

PLATE 7.

Fig. 1. *Cheirimedon Fougneri*, n. sp., upper antenna.   2. First gnathopod.
3. Second gnathopod.   4. Third peræopod.   5. Fifth peræopod.
6. Urus.

Fig. 7. *Cheirimedon Hansoni*, n. sp., upper antenna.   8. First gnathopod.
9. Second gnathopod.   10. Third peræopod.   11. Fifth peræopod.
12. Telson and 3rd uropods.

Fig. 13. *Orchomenopsis nodimanus*, n. sp., upper antenna.   14. First gnathopod.
14 *a*. Part of hind margin of same more highly magnified.   15. Third
peræopod.   16. Fifth peræopod.   17. Telson.

Fig. 18. *Orchomenopsis Rossi*, n. sp., upper antenna.   19. First gnathopod.
20. Second gnathopod.   21. Third peræopod.   22. Fifth peræopod.
23. Telson.

PLATE 8.

Fig. 24. *Orchomenella pinguides*, n. sp., upper antenna.   25. First gnathopod.
26. Second gnathopod.   27. Third peræopod.   28. Fifth peræopod.
29. Telson and 3rd uropods.   30. Third metasome-segment.

Fig. 31. *Orchomenella Franklini*, n. sp.   32: Head.   33. Upper antenna.   34.
First gnathopod.   35. Third peræopod.   36. Fifth peræopod.   37.
(Figure cancelled.)

Fig. 38. *Tryphosa Adarei*, n. sp.   39. Upper antenna.   40. First gnathopod.
41. Second gnathopod.   42. Third peræopod.   43. Fifth peræopod.
44. Telson.

PLATE 9.

Fig. 45. *Tryphosa Murrayi*, n. sp.   46. Upper antenna.   47. First gnathopod.
48. Second gnathopod.   49. Third peræopod.   50. Fifth peræopod.
51. Third uropods and telson.

Fig. 52. *Hoplonyx Stebbingi*, n. sp., upper antenna.   53. First gnathopod.
54. Second gnathopod.   55. Third peræopod.   56. Fifth peræopod.
57. Third uropods and telson.   57*. Third segment of metasome.

Fig. 58. *Ampelisca macrocephala*, Lilljeborg.   59. Third segment of metasome
and urosome.   60. Third peræopod.   61. Fifth peræopod.   61*.
Second uropods.

Fig. 62. *Oediceros Newnesi*, n. sp., upper antenna.   63. First gnathopod.   64.
Second gnathopod.   65. First peræopod.   66. Third uropods and
telson.

PLATE 10.

Figs. 67, 68. *Oediceros Newnesi*, seen from above and sideways.

Fig. 69. *Epimeria inermis*, n. sp.

Fig. 70. *Eusirus lævis*, n. sp.   71. Upper antenna.   72. Lower antenna.   73.
Palp of maxillipedes.   74. First gnathopod.   75. Second gnathopod.
76. Upper portion of 5th peræopod.

Figs. 77, 78. *Oradarea longimana*, n. g. & n. sp.   79. Third segment of meta-
          some.   80. Upper antenna.   81. Mandible.   82. Posterior lip.   83.
          First maxilla.   84. Second maxilla.   85. Maxillipedes.   86. First
          gnathopod.   87. Second gnathopod.   88. Fifth peræopod.   89. Third
          uropods and telson.

PLATE 11.

Fig. 90. *Atyloides serraticauda*, Stebbing.   Third segment of metasome.
Fig 91. *Atylus antarcticus*, n. sp.   92. Upper antenna.   93. First gnathopod.
          94. First peræopod.   95. Upper part of 3rd peræopod.   96. Upper
          part of 5th peræopod.   97. Third uropods and telson.
Fig. 98. *Jassa goniamera*, n. sp.   99. Upper antenna.   100. Maxillipedes.
          101. First gnathopod.   102. Second gnathopod.   103. First peræopod.
          104. Third peræopod.   105. Fifth peræopod.   106. Second and third
          uropods and telson.   106 *a*. Extremity of 3rd uropods.

On the Anatomy of the Pig-footed Bandicoot (*Chœropus
    castanotis*).   By F. G. PARSONS, F.L.S., Lecturer on Human
    and Comparative Anatomy at St. Thomas's Hospital, late
    Hunterian Professor at the Royal College of Surgeons of
    England.

(With 10 Figures in the Text.)

THE specimen from which the following notes were made was
kindly lent me by Prof. Elliot Smith.   So far as I can find out
little has been hitherto recorded about this animal's anatomy.
The skeleton is to be prepared for the Cambridge Zoological
Museum, so I have devoted my attention to the soft parts.

JOINTS.

The shoulder-joint has a well-marked gleno-humeral ligament
in the anterior part of its capsule; this band runs from the
dorsal side of the attachment of the biceps downward and out-
ward to the front of the lesser tuberosity of the humerus.

In the elbow the head of the radius lies antero-externally to
the articular surface of the ulna, it is a circular disc as in Man,
and pronation through about a quarter of a circle is possible;
the orbicular ligament, however, is only feebly marked.

In the wrist-joint the ulna hardly takes any part, the articulation is between the radius above and the scaphoid, semilunar, and cuneiform below, but there is a slight joint-cavity completely shut off from the rest between the ulna and the pisiform.

In the hip the ligamentum teres is well marked.

The knee is like that of most other mammals, the posterior attachment of the external semilunar cartilage is to the intercondylar notch of the femur, while the head of the fibula shows none of the freedom of movement so characteristic of many other marsupials *. In this typical mammalian knee *Chœropus* agrees with *Perameles* and differs from many other marsupials.

The internal lateral ligament of the ankle consists of tibionavicular and tibio-astragular bundles, while on the outer side the middle and posterior fasciculi of the external lateral ligament are present. As the tibia and fibula become synostosed in the lower half of the leg, there is no inferior tibio-fibular articulation.

THE MUSCLES.

Panniculus carnosus.—This is well developed and has the typical mammalian arrangement †. The abdomino-humeral part

Fig. 1.

1. Platysma. 2. Sphincter colli. 3. Retractor naris. 4. Orbicularis palpebrarum. 5. Frontalis. 6. Anterior auricular muscles.

is very well developed and, as usual, divides to enclose the pectoralis, but the part which passes superficial to that muscle

* " Joints of Mammals," Journ. of Anat. vol. xxxiv. p. 312.
† " Muscles of Mammals," Journ. of Anat. vol. xxxii. p. 428.

is specially well developed.   The achselbogen passing from the
dorso-humeralis across the axilla are well marked.   Deep to the
platysma is a very definite sphincter colli, which, however, does
not reach back so far as the sternum.   The facial muscles are
simple, and consist of a retractor naris rising below and in front
of the orbit and dividing into several fine tendons, orbicularis
oris and palpebrarum, frontalis, depressor labii inferioris, four
anterior auricular muscles and two posterior.   The most curious
of the facial muscles is one which I have never met with
in other mammals; it rises from the root of the zygoma and

Fig. 2.
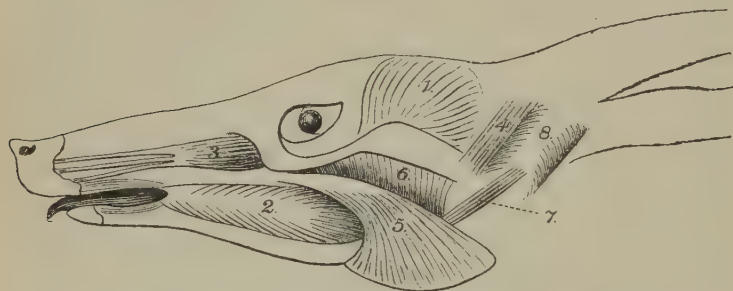
1. Temporal.   2. Buccinator.   3. Retractor naris.   4. Deep Parotido-auri-
cularis.   5. Superficial Masseter.   6. Deep Masseter.   7. Third part of
Masseter.   8. Auditory Meatus.

passes upward and backward, deep to the parotid, to be inserted
into the commencement of the helix.   I would suggest the name
of deep parotido-auricularis for it.   There is no distinct zygo-
maticus or levator labii superioris.

Muscles of Mastication.

The *Temporal* does not meet its fellow in the mid-line of the
skull, it is divided into two very distinct planes.

The *Masseter* also has the two planes very clearly separated :
the superficial rises by a narrow tendon from the malar, and
spreads out in a fan-like way to be inserted into the lower margin
of the mandible as far back as the tip of the angular process ;
the deep plane is also fan-shaped, but is inverted, the broad part
rising from the whole length of the zygoma, while the insertion
converges to the outer surface of the ramus of the jaw.

A third slip of the masseter which I have never found
in other mammals rises from the cartilage of the external

auditory meatus and runs obliquely downward and forward, as a narrow band, to be inserted into the outer surface of the ramus of the mandible deep to the portion of the masseter last described.

Fig. 3.

1. Infraorbital Nerve. 2. Buccinator. 3. Retractor naris (cut). 4. Angle of Mandible. 5. Superficial Masseter (cut). 6. Deep Masseter. 7. Third part of Masseter. 8. Auditory Meatus.

I think it is supplied by the third division of the fifth, but on this point I am not quite certain as the nerve was so extremely small.

The *Pterygoids* are remarkable for the lowness of their insertions : the externus, instead of passing to the condyle, is attached to the inner surface of the ramus just above the inferior

Fig. 4.

1. Temporal. 2. External Pterygoid. 3. Internal Pterygoid.
4. Inferior dental foramen.

dental foramen, which is also singularly low down; while the internus is inserted into the lower border of the mandible, which, as in all marsupials, is incurved. It is worth while considering

whether the characteristic inflection of the angle of the marsupial mandible may be due to the concentration of the pull of this internal pterygoid on the lower margin of the jaw.

The *Digastric* runs from the paroccipital process to the middle third of the mandible; it has the usual double nerve-supply and its central tendon, although very short, is distinct.

I noticed nothing special about the *Buccinator*.

Styloid Muscles.

No *Stylo-hyoid* was found.

The *Stylo-glossus* is large and distinct.

The *Stylo-pharyngeus* is also well marked, and has the glosso-pharyngeal nerve winding round its posterior border as in Man and other mammals.

Other Neck Muscles.

The *Sterno-mastoid* is a single muscle on each side, rising from the anterior (cephalic) border of the manubrium and being inserted into the paramastoid process; the spinal accessory nerve passes deep to it, and no representative of a cleido-mastoid was seen.

The *Omo-hyoid* is present; there is no sign of a central tendon or intersection.

The *Omo-trachelian* passes from the transverse process of the atlas to the tip of the acromion under cover of the trapezius.

Muscles joining the Shoulder to the Trunk.

Pectoralis.—This consists of three layers: α, the most super-ficial, rises from the manubrium and is inserted into the lower half of the humerus; β rises from the whole length of the sternum and is inserted into the middle third of the humerus; γ, the deepest part, rises from the linea alba for a short distance behind (caudal to) the xiphisternum, and passes deep to the other parts to be inserted into the humerus just below the lesser tuberosity. α and apparently a small part of β are supplied by the external anterior thoracic, while γ and the rest of β are supplied by the great internal anterior thoracic, which also supplies the greater part of the panniculus.

The *Cephalo-humeralis* rises from the occipital curved line and is inserted into the middle third of the humerus. If the cleido-occipital part of the sterno-mastoid is present it is entirely fused with this muscle.

The *Trapezius* rises by one continuous origin from the occipital crest, ligamentum nuchæ, and thoracic spines as far as the 11th; it is inserted partly into the cephalo-humeral, partly into the acromial process and spine of the scapula.

The *Rhomboid* also forms one continuous sheet rising from the occipital crest, ligamentum nuchæ, and anterior 6 thoracic spines; it is inserted into the vertebral border of the scapula.

The *Latissimus dorsi* rises from the 11th, 12th, and 13th ribs, the posterior 4 or 5 thoracic spines, and the lumbar fascia; it has the usual insertion into the surgical neck of the humerus.

The *Latissimo-olecranalis* (dorso-epitrochlearis) rises as usual from the latissimus dorsi and is inserted into the inner side of the olecranon.

The *Sterno-scapularis* rises from the manubrium close to the first rib and passes to the fascia over the supraspinatus; there is not even a fibrous intersection to mark the position of the clavicle.

Muscles of the Arm.

Deltoid.—The clavicular fibres, of course, form part of the cephalo-humeral. The acromial fibres are very scanty and, contrary to the rule in mammals, are inserted higher than those coming from the spine. The spinous portion is well developed, and is inserted about the junction of the upper and middle thirds of the humerus.

The *Scapular Muscles* show nothing of special interest. (The levator anguli scapulæ and serratus magnus are included with the trunk-muscles.)

The *Teres major* rises from the third of the axillary border nearest the angle, its insertion is entirely dorsal to that of the latissimus dorsi.

The *Teres minor* is very small and rises from the third of the axillary border nearest the glenoid cavity.

The *Coraco-brachialis* is entirely absent.

The *Biceps* has only the long head, which passes as usual through the capsule of the shoulder-joint.

The *Brachialis anticus* has only the long head, which rises from the back of the surgical neck of the humerus; it is entirely supplied by the musculo-cutaneous nerve. Owing to the necessity for preserving the skeleton for mounting, I am not quite certain as to the insertions of the last two muscles, but the biceps seemed to go entirely to the radius.

The *Triceps* has the usual three heads; of these the long and external unite, while the internal remains distinct to the insertion.

The *Pronator radii teres* is inserted into the junction of the upper third with the lower two-thirds of the radius, and at this point the bone suddenly curves.

The *Flexor carpi radialis* is inserted into the base of the radial metacarpal bone (metacarpal of medius).

The *Palmaris longus* is absent.

The *Flexor sublimis digitorum* rises from the internal condyle and splits into two for the two digits (medius and annularis). The tendons are perforated as usual, but the ring noticed in Rodentia, Insectivora, and Carnivora was not seen *.

The *Flexor carpi ulnaris* is absent—a fact which interests me, as I do not remember a similar occurrence in any other mammal.

The *Flexor profundus digitorum* has three distinct heads—one from the internal condyle, one from the olecranon, and one from the upper third of the radius and ulna.

The general morphology of this muscle in mammals will be found in the reference just given, and it seems to me that the head from the condyle is the radio-condylar; that from the olecranon is the ulno-condylar which has slipped down, although it is true that when this slips down in the Primates it is the coronoid instead of the olecranon which it goes to; while the head from the radius and ulna is the fused radial and ulnar heads.

Only one *Lumbrical* is present, and that comes from the tendon to the annularis.

The *Pronator quadratus* is attached to the lower third of the radius and ulna.

The *Epitrochleo-anconeus* is absent.

The *Anconeus* is remarkable for having a broader attachment to the humerus than to the ulna.

There is only one *Extensor carpi radialis*, and this passes from the external supracondylar ridge to the base of the metacarpal bone of the medius; it therefore probably is extensor carpi radialis brevior.

The *Extensor communis digitorum*, like the flexor sublimis and profundus, gives off two tendons to the medius and annularis.

The *Extensor minimi digiti* is a distinct muscle rising from

* "Muscles of Mammals," Journ. of Anat. vol. xxxii. p. 731.

the external condyle and joining the tendon of insertion of the extensor communis to the annularis.

The *Extensor carpi ulnaris*, unlike its corresponding flexor, is well developed and is inserted into the base of the rudimentary metacarpal bone of the fifth digit (minimus).

The *Supinator brevis* passes as usual from the external condyle to the upper fourth of the radius ; it has only one layer, deep to which the posterior interosseous nerve passes, and no sesamoid bone is developed in its tendon.

The deep extensors are represented by only one muscle, which rises from the extensor surface of the ulna and joins the extensor communis tendon to the medius ; its large origin is like that of the extensor ossis metacarpi pollicis, while its insertion is that of the extensor profundus, of which the extensor indicis is the only remnant in Man. Probably both these elements have been fused into the single muscle found in *Chœropus*.

The *Muscles of the Palm* are very simple and consist of two double-headed flexores breves, one for the medius, the other for the annularis. Dorsal to these there is absolutely no muscle at all, neither are there any adductors superficial to them.

Muscles of the Trunk.

The *Rectus abdominis* runs from the pubis to the first rib ; no lineæ transversæ could be made out in it, although they were carefully looked for.

The *Pyramidalis* is not well marked ; it rises from the inner side of the marsupial bone and is inserted into the linea alba about one third of the way from the pubis to the xiphisternum.

The *External oblique* rises from the fifth to the thirteenth rib ; five lineæ transversæ were seen in it.

The *Supracostalis* is present, though small ; it rises from the junction of the second rib with the sternum and ruus outward and forward to be inserted into the first rib.

The *Internal oblique* and *Transversalis* are inseparable ; they both help to form the cremaster which runs down on the cord, being specially strong on its outer side, and spreads out to form a well-marked muscular bag for the testis, so that each testis lies in a separate muscular bag.

The *Serratus magnus* and *Levator anguli scapulæ* (*Serratus ventralis*) as usual form one muscular sheet which rises from the lower four cervical vertebræ and from the first eight ribs.

The *Scalenus ventralis* (*anticus*) is absent.

The *Scalenus longus* rises from the 3rd, 4th, 5th, and 6th cervical transverse processes and is inserted into the first four ribs.

The *Scalenus brevis* is dorsal to the last, it rises from the 6th cervical vertebra and is inserted into the first rib.

Muscles of the Hind Limb.

As in most of the Mammalia, the sartorius, ectogluteus, caudo-femoralis, and biceps form one sheet ; the only special point being that between the sartorius and the ectogluteus there is no distinct tensor fasciæ femoris, unless the muscle which I here call ecto-gluteus is really tensor fasciæ femoris.

The *Sartorius* runs from the iliac crest to the inner side of the patella. I satisfied myself that it was supplied by the superior gluteal nerve, a point of some little interest when the myology of other mammals is considered.

The *Ectogluteus* passes from the anterior caudal vertebræ and sacrum, and is inserted chiefly into the fascia of the thigh, but slightly into the third trochanter of the femur.

The *Caudo-femoralis* (*Agitator caudæ*) continues the origin of the last muscle back along the caudal vertebræ, and is inserted by a narrow tendon into the outer side of the top of the patella ; in the buttock it is much thicker and more bulky than the ectogluteus.

The *Biceps* (*Flexor cruris lateralis*) is a one-headed muscle rising from the tuber ischii ; it is inserted entirely into the fascia of the leg from the knee halfway down.

The *Mesogluteus* (*Gluteus medius*) rises from the iliac crest and sacrum, and is inserted into the outer side of the great trochanter and somewhat below.

The *Entogluteus* (*G. minimus*) runs from the dorsal part of the gluteal surface of the ilium to the top of the great trochanter.

The *Gluteus ventralis* (*G. quartus-scansorius*) rises from the ventral part of the guteal surface of the ilium, and is inserted into the front of the great trochanter.

All the above-mentioned muscles, with the exception of the biceps, are supplied by the superior gluteal nerve, which emerges from the sciatic notch anterior to (cephalad) the pyriformis. The biceps, however, is supplied by the nerve to the hamstrings which comes out of the notch behind (caudad) the pyriformis.

The *Pectineus* is single and small.

The *Adductor Mass* is with difficulty separable into two planes: the more anterior is adductor longus and is inserted into the middle third of the femur; the rest comprises the brevis and magnus and is attached to the lower half of the femur.

The *Gracilis* is single and has the usual attachments; below it is slightly connected with the semitendinosus.

In the *Quadriceps extensor cruris* there is absolutely no reflected head to the rectus femoris, while the vastus externus is, as usual, larger than the internus.

The *Short Rotators of the Hip* show nothing of special interest.

The *Semitendinosus* rises from the anterior caudal vertebræ and the tuber ischii; in the lower part of the thigh it divides into two parts, the larger of which has the usual insertion into the inner side of the top of the shaft of the tibia, while the smaller slip joins the insertion of the biceps on the outer side of the leg. From the insertion of the internal, larger part of the muscle, a tendinous cord runs down along the inner side of the tendo Achillis to be inserted into the tuber calcis.

The *Semimembranosus* and *Presemimembranosus* are closely connected in their whole extent; they rise from the tuber ischii, and in the lower part of the thigh the presemimembranosus is inserted into the lower fourth of the back of the femur, while the semimembranosus passes as usual to the inner side of the head of the tibia deep to the internal lateral ligament. It is interesting to notice that between the presemimembranosus and the adductor mass there is no connection at all.

The *Tibialis anticus* rises from the upper fourth of the external surface of the tibia; it has no femoral origin and is inserted into the base of the metatarsals of the rudimentary index and medius toes.

There is no *Extensor proprius hallucis*.

The *Extensor longus digitorum* is peculiar: it rises close to the tibialis anticus from the upper fourth of the outer surface of the tibia and divides into two planes; the more superficial of these sends one long tendon to the middle and distal phalanges of the big annularis toe, while the deep plane sends a similar tendon to the proximal phalanx of the same toe.

The *Extensor brevis digitorum* is reduced to a mere fibrous band which runs from the calcaneum to the extensor tendon.

The *Peroneus longus* rises from the head and upper fourth of the fibula, it runs through a bony tunnel in the sole and is

inserted into the metatarsals of the rudimentary internal toes (index and medius).

The *Peroneus brevis* rises from the fibula in front of the last, and is inserted into the base of the metatarsal bone of the fifth toe (minimus).

The *Peroneus quinti digiti* comes from the second quarter of the fibula and is inserted into the dorsum of the terminal phalanx of the fifth toe. It will be seen that this is the only extensor tendon of the fifth toe.

The two heads of the *Gastrocnemius* rise from just above the condyles; in the origin of the outer one a flabella is developed. The tendons from these two bellies with that of the plantaris are twisted in the rope-like manner so often seen in mammals *, and are inserted as usual into the calcaneum. From the inner side of the tendon just above its insertion a curious oblique band of fibres runs downward and forward to be inserted into the plantar fascia; I have not seen this in any other mammal.

The *Plantaris* is larger in bulk than either head of the gastrocnemius; it rises from the flabella behind the external condyle and its tendon winds round in the usual way from the deep to the superficial aspect of the tendo Achillis. In the sole it forms a tough fibrous sheet which divides for the 2nd, 3rd, and 4th toes, each slip forming a flexor perforatus and being inserted into the middle phalanx.

The *Popliteus* is small and has the usual attachments, it is inserted into the upper eighth of the posterior surface of the tibia.

The *Rotator fibulæ* is so slight as to be almost unrecognizable, it forms a very feeble deep layer of the last muscle; in this animal there is no movement between the tibia and fibula.

The *Flexor tibialis* and *Flexor fibularis* rise from the upper half of the tibia and fibula, their tendons fuse in the sole and eventually form the flexores perforantes for the 2nd, 3rd, and 4th digits (index, medius, and annularis). As in the hand, there is one lumbrical for the annularis digit.

The *Sole Muscles* consist only of three flexores breves, which, as usual, are double-headed; one of these is common to the rudimentary index and medius digits, one belongs to the great annularis and one to the minimus; this flexor brevis of the minimus is the only flexor muscle of that digit.

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* "Morphology of the Tendo Achillis," Journ. of Anat. xxviii. p. 414.

THE VASCULAR SYSTEM.

The following are some points about the vessels which appeared to me interesting. The aortic arch only gives off two branches, the innominate and the left subclavian; the former after giving off the right subclavian divides into right and left carotids *.

Fig. 5.
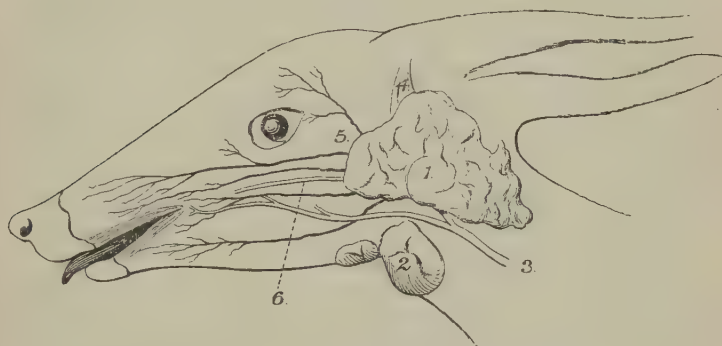
1. Parotid gland.   2. Submaxillary gland.   3. External Jugular vein.
4. Deep Parotido-auricularis muscle.   5. Placed just above the transverse facial artery (the other black lines represent the branches of the Facial Nerve).
6. Parotid (Stensen's) duct.

The face is supplied, as in many other long-faced mammals, not by a facial artery coming over the mandible as in Man, but by a branch which comes off from the root of the temporal artery at the termination of the external carotid, and which is represented, I suppose, by the transverse facial artery of Man.

The brachial artery passes through the supracondylar foramen with the median nerve, and then continues down the forearm with that nerve as a median artery until the palm is reached. The aorta terminates in the usual marsupial method, the two external iliacs coming off some distance above the two internal. The femoral artery gives off a large saphenous branch in the lower part of the thigh; this reaches the posterior surface of the tibia and eventually the sole of the foot.

There are two prevenæ cavæ; the post vena cava lies ventral to the termination of the abdominal aorta, as is so often the case among marsupials.

* " Arrangement of Branches of Mammalian Aortic Arch," Journ. of Anat. vol. xxxvi. p. 394.

THE NERVOUS SYSTEM.

The *Brachial plexus* is formed by the 5th, 6th, 7th, and 8th cervical and part of the 1st thoracic nerve, its arrangement is singularly like that of Man.

The *Musculo-cutaneous nerve* comes from the 6th and 7th cervical and supplies the biceps brachialis anticus and the skin of the outer side of the forearm.

The *Median nerve* rises by the usual two heads and gets its fibres from the 6th, 7th, 8th cervical and 1st thoracic nerves; it passes through the supracondylar foramen with the brachial artery, supplies all the muscles of the flexor surface of the forearm except the greater part of the flexor profundus digitorum, and then accompanies the median artery to the palm, where it ends by supplying the two digits.

The *Ulnar nerve* comes from the 8th cervical and 1st thoracic; as the minimus digit is suppressed it ends in the flexor profundus digitorum.

The *Internal cutaneous* supplies the inner side of the forearm with cutaneous twigs.

The *Internal anterior thoracic* is, as usual in the lower mammals, very large; it supplies all the ventral part of the panniculus, and apparently some at least of the dorsal part, as well as a great deal of the pectoral mass. The more cephalic part of this mass is supplied by the *external anterior thoracic* from the 6th and 7th cervical.

The *Musculo-spiral nerve* comes from all the nerves forming the plexus except the 5th cervical. After supplying the triceps and the skin of the arm, it divides at the elbow into radial and posterior interosseous, the former of which supplies the dorsal surfaces of the two digits, while the latter passes deep to the supinator brevis and supplies the muscles on the dorsal surface of the forearm, ending, as usual, on the dorsum of the carpus. In the Kangaroo and Phalanger I have found that the area usually supplied by the radial has a branch from the median instead. *Chœropus* shows that this is not a constant occurrence in marsupials.

The *Circumflex nerve* as usual supplies the deltoid, teres minor, and skin over the deltoid. I failed to find any gangliform enlargement on the nerve to the teres minor.

Owing to the necessity of keeping the skeleton intact I was unable to be quite sure of the arrangement of the lumbo-sacral plexus. I shall therefore omit its description.
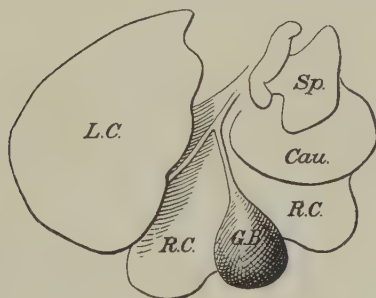
VISCERA.

The *Left Lung* is not divided into lobes.

The *Right Lung* has a well-marked azygos lobe and a slight fissure near the ventral margin. There is an eparterial bronchus on the right side only.

The *Liver* has the same four lobes that are found in Man, if the quadrate is not counted as a primary lobe; but it will be

Fig. 6.

Caudal surface of Liver. L.C. Left central lobe. R.C. Right central lobe.
G.B. Gall-bladder. Cau. Caudate lobe. Sp. Spigelian lobe.

noticed that the gall-bladder divides the right central lobe into two parts, the more median of which would of course correspond to Man's quadrate lobe. The lobe which I have named caudate occupies the usual position of the mammalian caudate lobe, that is to say, it rests upon the right kidney; this is my only reason for regarding it as caudate rather than right lateral. The gall-bladder, it will be noticed, is rather large.

The *Stomach* is remarkable for the great size of the cardiac portion as well as for the attempt at a marking off of a small secondary chamber or pyloric antrum.

The *Small Intestine* is 18 inches from the pylorus to the ileo-cæcal valve; the length of the body from the snout to the root of the tail is 10 inches: the small intestine is therefore $1\frac{4}{5}$ the length of the body.

The *Ileo-cæcal valve* is a flat disc-like protrusion in the cæcum with a puckered orifice, the edges of which are in close apposition.

The *Cæcum* is 4 inches long and is connected by a meso-cæcum with the lower part of the small intestine.
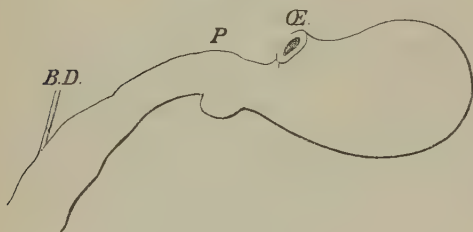
Fig. 7.   Fig. 8.

Fig. 9.

Fig. 7.—Stomach. Œ. Œsophagus. P. Pylorus. B.D. Bile-duct.
Fig. 8.—Cæcum laid open to show Ileo-cæcal valve.
Fig. 9.—C. Colon. Cœ. Cæcum. S.I. Small intestine.

The *Colon* and *Rectum* measure $10\frac{1}{2}$ inches together.

The *Spleen* was entirely absent. I feel quite positive on this point, as I searched for it with the greatest care, and all the viscera were examined immediately after the abdomen was opened, so that it could not have been removed in my absence. I have recently been told that there are one or two recorded cases of absence of the spleen in Mammals, though I have been unable to

trace the records; and when one considers how very comfortably men and animals live after its removal one wonders that it should not be more often absent. I looked to see whether there were any signs of the spleen having been removed during life, but could find no signs of a scar in the abdominal wall or any traces of ligatured vessels.

The *Kidneys* are in the usual position, the right one $\frac{1}{2}$ inch nearer the head than the left.

The *Adrenals* are separate from the kidneys and near the great vessels, the right one slightly more cephalic than the left.

The *Bladder* is small and somewhat fusiform in shape, while the Prostate is very large.

Fig. 10.

α. Corpus spongiosum. *β, γ.* Cowperian glands. R. Rectum.
P. Penis. S. Scrotum.

The *Testes* are remarkable for their wide separation from the epididymes, and there is a distinct fold of visceral tunica vaginalis running from the one to the other. The globus minor of the epididymis is larger than the globus major.

The *Penis* has an S-shaped curve, and its terminal portion lies

along the ventral wall of the rectum; at the second curve, which
forms a sharp kink, two muscular bands or retractors are attached,
the other ends of which run to the ventral wall of the rectum.
On each side of the rectum are situated four glandular masses of
spherical shape. Three of these (a, β, and γ) are shown in the
diagram (fig. 10); the fourth one is small and is hidden by the one
marked γ. On section γ shows a series of concentric fibrous
planes of a pale colour, while the darker soft tissue between is on
microscopic examination seen to be glandular. Prof. A. H.
Young has referred in detail to these bodies in the Koala (Journ.
Anat. & Phys. vol. xiii. p. 316), and he has pointed out that,
while three of them are Cowperian glands, the fourth (corre-
sponding to a in fig. 10) is one half of the divided corpus
spongiosum. This conclusion a section of a compared with that
of γ seemed to bear out, though the specimen had not been
well enough preserved for careful microscopic study.

Further Notes on the Lemurs, with especial Reference to the
Brain. By G. ELLIOT SMITH, M.D. (Communicated by
Prof. G. B. HOWES, D.Sc., LL.D., F.R.S., Sec.L.S.)

[Read 5th March, 1903.]

(With 4 text-figures.)

SINCE my memoir on the Prosimian brain was presented to the
Society *, I have come into possession of some valuable material
which is of sufficient interest to call for these additional notes.
At the same time, I shall avail myself of the opportunity of
referring to some interesting communications of Hubrecht † and
Earle ‡, with which I was not acquainted when my memoir was
written. Professor Howes has called my attention to these, and
generously lent me copies of them.

* Trans. Linn. Soc., Ser. II. Zool. vol. viii. pp. 319–432. References in this
paper under "Mem." refer to the illustrations of the memoir.

† A. A. W. Hubrecht, "The Descent of the Primates," Princeton Lectures,
New York, 1897. (Compare also "Die Keimblase von Tarsius," Festschrift
für Carl Gegenbaur, Leipsig, 1896.)

‡ Charles Earle, "The Lemurs as Ancestors of the Apes," 'Natural
Science,' vol. x. no. 63, May 1897.

Id., "On the Affinities of *Tarsius*: a Contribution to the Phylogeny of
the Primates," The American Naturalist, vol. xxxi. July 1897, pp. 367 *et seq.*

The Brain of Globilemur.

The consideration of the features of this brain led me in my Memoir to such indecisive and unsatisfactory results, that no apology is needed for again returning to the study of a form of such interest.

The British Museum has recently acquired fragments of two crania of *Nesopithecus*, a genus which is either identical with or very closely related to *Globilemur*. Plaster moulds of the brain-cavity of these fragments were made, and, at the kind suggestion of Dr. Forsyth Major, replicas of the casts were sent to me by Dr. Smith Woodward.

Fig. A.
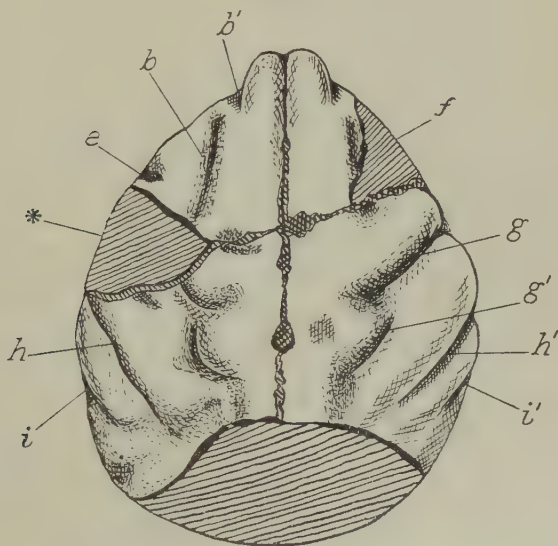
One of these (fig. A) represents a considerable part of the dorsal aspect of the brain ; but, unfortunately, it does not show any part below the level of the reference-line *g* in fig. 40 of my memoir. The second cast represents only the anterior extremities of the cerebral hemispheres, *i. e.* the area containing the coronal, diagonal, and orbital sulci.

Unlike the complete cast described in the body of my memoir (Mem. figs. 39 and 40), these two fragments exhibit deep and exceedingly well-defined sulci. This fact, however, only renders the incompleteness of the specimens all the more tantalizing,

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since the information which would be conveyed by the small missing fragments (fig. A, * and *f*) would have enabled us to decide with absolute certainty all the doubtful issues raised in the previous discussion.

In the smaller fragment, the coronal and diagonal sulci are exceptionally deep and sharply defined, so that their identity is placed beyond all doubt. In shape and position they closely resemble the furrows *b* and *e* (Mem. fig. 40) in the type-specimen. In the other specimen (fig. A) the coronal sulcus is broken up on both sides into a small anterior (? prorean) fragment (*b'*) and a long posterior sagittal furrow (*b*). The gyrus included between the coronal sulcus and the interhemispheral cleft is 7 mm. broad in front and 11 mm. broad at its posterior extremity. The relative smallness of this gyrus is in marked contrast with its size in the Apes and even in most Lemurs. Thus the corresponding measurements in a specimen of *Cercopithecus patas* are 6 mm. and 20 mm. respectively, and in a *Lemur macaco* 4 mm. and 13 mm. respectively. In other words, both in Apes and Lemurs the coronal sulcus is more oblique and the area to its mesial side more extensive than in *Nesopithecus*. In this particular *Nesopithecus* approximates nearer to the primitive condition than either *Lemur* or *Cercopithecus*.

The position of the diagonal sulcus (*e*) is noteworthy. In the Indrisinæ this furrow is placed within the orbital depression, *i. e.* below the orbital margin; in *Lemur* it extends on to the orbital margin, but is placed mainly in the orbital depression; whereas in *Nesopithecus* (*Globilemur*) it is placed *wholly above* the orbital margin. In this respect *Globilemur* resembles the Apes.

The long furrow labelled *g* in the type-specimen (Mem. figs. 39 and 40) is in the present one seen to consist of two separate sulci—an obliquely-placed anterior element (*g*), the upper extremity of which overlaps a small comma-shaped furrow (*g'*). The latter almost certainly represents a "lateral" (intraparietal) sulcus. I cannot confidently express a definite opinion as to the identity of the furrow labelled *g*, *i. e.* the anterior oblique element; but the condition exhibited in this specimen does not lend any support to the view that it is in any part of the Sylvian fissure. Nor can I confidently regard it as a separate part of the lateral, because such a breaking-up of that is almost unknown, except in the Simiidæ and Man.

A direct comparison of this brain with that of an Ape, and especially such an Ape as *Cebus*, suggests the identity of this furrow (*g*) with the sulcus centralis (Rolandi).

If this is so—and the imperfect state of the specimen does not permit me to do more than suggest the interpretation—the position and direction of the sulcus are distinctly pithecoid, and in marked contrast with the Prosimian relations of the central sulcus.

Perhaps the most interesting feature in this cast is the existence of a well-defined furrow, corresponding to the slight depression labelled *h* (which I represented in a very doubtful manner in figs. 39 and 40 of my memoir). The fragment containing the lower end of this sulcus is unfortunatety missing. Nevertheless it seems probable that this furrow represents the Sylvian fissure, having a position and an extremely oblique direction such as are found elsewhere only in the Apes. Behind it there is a second oblique furrow (*i*), which must be the parallel (postsylvian) sulcus, if *h* be regarded as the Sylvian fissure.

The shape of the brain and the disposition of its furrows in *Nesopithecus* are therefore much more pithecoid than those of any other Prosimian, and, in Forsyth Major's words, it " departs from the Lemurids and approaches the Cebidæ and Cercopithecidæ" (Proc. Royal Society, vol. lxii. 1898). In spite of these resemblances to the Apes, the conformation of the olfactory region of the brain and the relations of cerebrum to cerebellum point decisively to the Prosimian status of *Globilemur*.

If this interpretation of the sulci is correct (and, with the knowledge of the condition presented by this specimen, I cannot suggest any alternative scheme which is even plausible), the brain of *Nesopithecus* presents a strange mixture of decidedly pithecoid and equally decided Prosimian features side by side. The shape of the brain is distinctly Cercopithecoid, the plan and direction of its sulci (and consequently the mode of subdivision of the neopallium) diverge widely from the common Lemurid arrangement, and closely resemble those of the Cebidæ and Cercopithecidæ. On the other hand, there are the distinctly Prosimian characters already mentioned , and yet *Nesopithecus*, unlike the other connecting link, *Tarsius*, shows no indications of being a primitive type. To attempt to explain this strangely mixed association of characters on the evidence of the brain would be sheer guesswork. In fact one could wish for no

stronger argument to oppose to those who hold that Lemurs and Apes belong to separate orders, than the mere exhibition of the brain of *Nesopithecus*.

The Brain of Propithecus.

When the memoir on the Prosimian brain was written I had not seen the actual brain of any of the Indrisinæ, and had to draw my data from the examination of cranial casts, studied, however, in the light of Milne-Edwards's descriptions of the actual brains. Within the last three months Professor J. T. Wilson, of the University of Sydney, has kindly placed at my disposal a series of young and fœtal Indrisinæ labelled " *Indris diadema*," which had been in spirit for a considerable time in the stores

Fig. B.
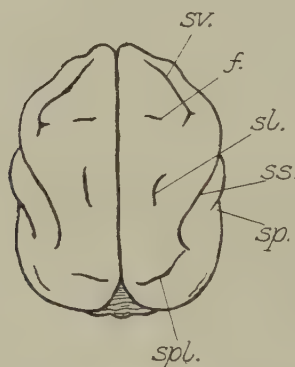
of the Australian Museum. In the oldest specimen (in which the first teeth were just cutting the gums) the full complement of cerebral sulci was present; but in the rest no furrows, except the hippocampal and rhinal fissures, had yet made their appearance.

I shall merely describe the arrangement of the sulci and the most salient features of the largest specimen. The length of the cerebral hemisphere is 31 mm., and the breadth of the two hemispheres 26·5 mm. As Milne-Edwards and Forsyth Major have already observed in reference to the young *Propithecus*, the cerebellum is almost completely hidden by the cerebrum (fig B). That this covering of the cerebellum is really due to an exceptionally great caudal extension of the cerebrum is shown by

an examination of the mesial aspect of the hemisphere (fig. C).
In this specimen 12 mm. out of a total length of 31 mm. lie on
the caudal side of the splenium of the corpus callosum; whereas
in an adult *Lemur fulvus* only 11 mm. out of a total length of
41 mm. lie behind the splenium.

There is a typical coronal sulcus (*s.co.*) with a bifid posterior
extremity such as commonly occurs in the genus *Lemur* (Mem.
fig. 1), *Globilemur* (Mem. figs. 39 & 40), and, perhaps, in
Indris (Mem. fig. 30). This exact form of coronal sulcus was
present in only one (Mem. fig. 29) of the crania of *Propithecus*
examined.

Both the orbital and diagonal sulci present a simple linear
form, and occupy that peculiar position entirely within the

Fig. C.   Fig. C'.
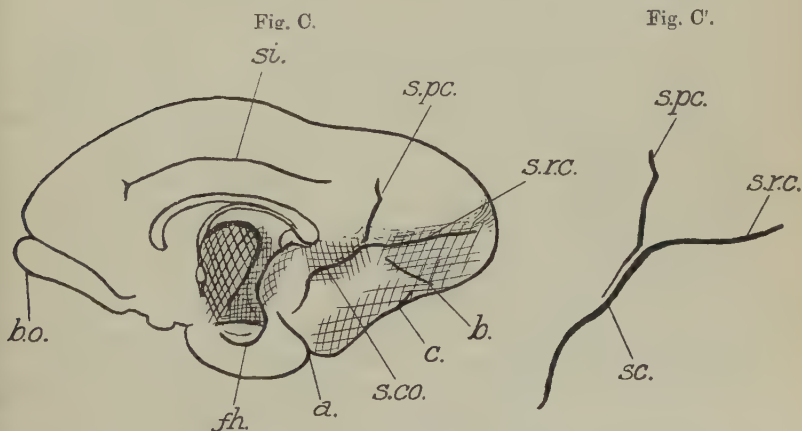
orbital area which seems to be so characteristic of the Indrisinæ
(Mem. fig. 28). The orbital sulcus is placed very close to and
parallel with the olfactory bulb, whereas the diagonal sulcus is
parallel to and entirely below the orbital margin.

As we have already noticed in some of the casts of *Propithecus*
(Mem. fig. 22), the sulcus *f* (*i. e.* the supposed dorsal element
of the central sulcus) is distinctly transverse, and not oblique as
in *Lemur* and *Nycticebus*.

This specimen resembles *Indris* and differs from all my speci-
mens of *Propithecus* (with the possible exception of that repre-
sented in Mem. fig. 29) in regard to the form of the Sylvian fissure
and the lateral sulcus. The latter (fig. B, *sl.*) is exceedingly

small, and is far removed both from the coronal (*sco.*) and post-lateral (*spl.*) sulci. To compensate for its diminutive size, the suprasylvian sulcus (*ss.*) is prolonged far back into a hook-like extremity; and on the right hemisphere it almost fuses with the lateral extremity of the post-lateral sulcus (*spl.*). It is instructive to recall in this connection that in those Apes, such as the Lemurine Dourocoli (*Aotus felinus*), in which the sulcus intra-parietalis becomes confluent with the suprasylvian sulcus, a small furrow persists in the position where the anterior end of the intraparietal (lateral) sulcus would be found if the fusion had not taken place (*vide* fig. 229, p. 391, Catalogue of the Royal College of Surgeons, 2nd edition, vol. ii.). This seems to point to the conclusion that in those Lemurs (e. g. *Nycticebus*) and Apes (many of the Cebidæ) in which the suprasylvian (Sylvian) and lateral (intraparietal) sulci appear to become confluent, it is a case of the more stable suprasylvian sulcus being mechanically prolonged, to relieve the tension of the expanding cortex, which would otherwise be accommodated by the lateral sulcus rather than a real confluence of the two sulci. In favour of this inter-pretation it is to be noted that a submerged gyrus indicating the site of the supposed union of the lateral and suprasylvian elements never occurs (so far as I am aware), whereas in those cases where two sulci become confluent (*e. g.* in the case of the calcarine-retrocalcarine junction) a submerged gyrus frequently occurs to indicate the site of the junction. On this hypothesis alone, it seems to me, can we explain the development in such cases of the aborted lateral element (fig. B, *sl.*).

Although the lower extremity of the suprasylvian sulcus does not emerge from the Sylvian complex on the surface of the brain (compare *Lemur*, *Perodicticus*, inter alia), the separation of the lips of the "Sylvian fissure" reveals the fact that it is composed of two distinct sulci (suprasylvian and pseudosylvian) bounding a tri-angular submerged area, as in the genus *Lemur* (Mem. fig. 6, *a*). It is of interest to note, however, that the opercular anterior lip of the suprasylvian sulcus is relatively greater (*i. e.* more pithe-coid) than it is in the adult *Lemur*.

I can find no trace of the rhinal fissure, except on the mesial surface of the hemisphere (fig. C, *a*), where it presents a form such as we are already familiar with in *Lemur* (Mem. fig. 5, *a*).

There is a typical postsylvian sulcus (Mem. fig. 6, *sp.*).

On the mesial surface there is no rostral nor genual sulcus.

There is a typical long intercalary furrow (*si.*) and the characteristic triradiate calcarine group. The calcarine sulcus (*sc.*) is confluent with the retrocalcarine (*s.r.c.*). The paracalcarine sulcus (*s.pc.*) is separated from the calcarine by a deeply submerged narrow gyrus (fig. C').

The mesencephalic depression on the hemisphere is more extensive than it is in the adult *Lemur*, so that the calcarine sulcus is placed within it as far back as its apparent bifurcation.

The furrows *b* and *c*, already noted in the brain of *Lemur* (Mem. fig. 5), are present here also.

There is a small hippocampal tubercle. There is no posterior cornu of the lateral ventricle.

The cerebellum so closely resembles that of *Lemur* that no special account is demanded.

The extraordinary variability of the disposition of the sulci in *Propithecus* is such as could have been produced only by retrogressive changes from a type more richly supplied with cerebral furrows.

The Brain of Lemur macaco.

I trust to have abundantly shown in the body of the aforenamed memoir that the great desideratum in the study of an organ which exhibits great variability is a large number of accurate records. No apology is needed, therefore, for adding notes, even in reference to the genus *Lemur*.

I have recently received from Captain Stanley Flower the body of an adult female *Lemur macaco*, from which I obtained a fresh brain.

The cerebellum is exposed to the same extent as that delineated in fig. 3 of my memoir. The cerebral hemisphere is 46 mm. long, and the two hemispheres together 37 mm. broad.

The rhinal fissure presents the usual form (*cf.* Mem. fig. 7), only the angle being definitely developed.

The orbital and diagonal sulci are present and well-developed, and occupy the positions characteristic of the genus *Lemur* (Mem. fig. 6), *i. e.* the diagonal does not cross the orbital margin.

There is an extensive, simple, linear coronal sulcus on the right hemisphere; on the left side its caudal end is bifid; a simple, obliquely-placed, comma-shaped sulcus *f* in the usual position (Mem. fig. 1); the extensive lateral sulci are symmetrical, and both resemble that shown on the left hemisphere

in the figure. The upper end of the suprasylvian sulcus is also
disposed like that of the left hemisphere in Mem. fig. 1 ; the
upper end of the postsylvian sulcus is bent forward, very slightly
on the right hemisphere, but more decidedly on the left side
(compare Mem. fig. 7). The lower end of the suprasylvian
sulcus is exposed on the surface to an exceptionally great extent.

Fig. 4 of the memoir accurately represents the basal surface of
this specimen in all except three points : the rhinal fissure (*fr.*) is
incomplete, the diagonal sulci (*sd.*) do not extend to the margins
of the orbital surfaces, and the lower end of the suprasylvian
sulcus (*i. e.* its exposed part) is distinctly visible.

The mesial surface of each hemisphere is exactly like that
represented in fig. 5 of the memoir in every respect, except that
there is no genual sulcus (*sg.*) and the intercalary sulcus is
shorter, *i. e.* does not extend backward so far.

General Considerations.

In the memoir on the Prosimian brain I disclaimed any pre-
tension to settle the question as to the relationship of the
Lemurs to the Apes and other Mammalia, and merely attempted
to state in decided and unequivocal language the nature and
value of the evidence of cerebral anatomy concerning the vexed
question of kinship. No problem as to the closeness of the
bonds of affinity which link together various mammalian families
can be adequately decided on the evidence of one region of the
body alone, even though this be so important and representative
an organ as the brain.

I return to this aspect of the subject only because I was
ignorant of the above quoted memoirs of Hubrecht and Earle
when my memoir was written.

The aim of Hubrecht's researches is chiefly to demonstrate
the intimate relationship of *Tarsius* to the Apes, and the wide
gap which separates it from the Lemurs. In his own words :—
" *Tarsius* is not a Lemur at all, . . . it should never have been
placed alongside the Lemurs, . . . its position is somewhere between
an unknown type of Insectivores and our modern monkeys and
Man " (*op. cit.* p. 16).

These views are based chiefly on the evidence of placental
anatomy, the validity of which Sir William Turner long ago
refused to acknowledge, in view of the fact that the testimony of
the teeth, the skeleton, the unguiculate digits, the calcarine

region of the brain, and the mammary glands points to a different conclusion. Hubrecht calls in the evidence of the teeth to support his contention; but, as Leche and Earle (*op. cit.*) have demonstrated, the full study of the teeth of *Tarsius* shows it to be " a Lemur beyond all doubt." The arguments of Hubrecht have been so thoroughly criticized by Earle in the memoirs quoted, that it is quite unnecessary to enter into details here. In opposition to Hubrecht's statements that in " very many respects *Tarsius* does not fit in with the Lemurs at all," and that its incisors and canines " resemble more closely those of the Insectivora than [those] . . . of the Lemurs " (*op. cit.* p. 11), it is, however, well to recall the fact that the brain of *Tarsius* exhibits decisive evidence of its Lemuroid status in the calcarine region, in the Sylvian fissure, and in numerous other traits which have been enumerated in the body of my memoir. In the degree of caudal extension of its hemispheres, it is even farther removed from the Insectivora and more pithecoid than the Lemurs.

Hubrecht's memoir is of special interest, because it emphasizes the undoubted fact that *Tarsius* is more nearly related to the Apes than are the Lemurs. This is also demonstrated in the brain by the relative microsmatism, the great caudal extension of the hemispheres, and the presence of a definite posterior cornu in the lateral ventricle. But the evidence of cerebral anatomy lends no more support than, I believe, the structure of the rest of the body does to the view that the approximation of *Tarsius* to the Apes implies its separation from the Lemurs. So far as its brain is concerned, *Tarsius* is a " Lemur of Lemurs," to use an expression of Professor Howes: it is certainly more nearly related to the Apes than most other Lemurs ; but, on the other hand, all the Apes and Lemurs are linked by a much closer bond of affinity the one to the other than are any of them to the other mammals. *Tarsius* is unquestionably the most primitive living Primate.

I have not deemed it necessary to refer in detail to the excellent memoirs of Charles Earle, because they so nearly express the views to which I have been led from the study of the brain.

Cerataphis lataniæ, a peculiar Aphid.   By ALICE L. EMBLETON,
      B.Sc.; 1851 Exhibition Science Research Scholar.   (Com-
      municated by Prof. G. B. HOWES, D.Sc., LL.D., F.R.S.,
      Sec.L.S.)

(PLATE **12**.)

IN the autumn of 1901, Mr. Lamb, of Cambridge, noticed this
insect on various orchids in one of the tropical houses at the
University Botanic Garden.   Through the kindness of Dr. D.
Sharp it was brought to my notice, and this paper is the result
of some investigations carried out with his assistance.   I wish
here to express my sincere thanks to him for all the valuable
help he has given me.

   The chief interest in this creature centres round its life-
history, which exhibits some remarkable biological features, very
little understood up to the present.   Many notes have been
written on the insect, but its extraordinary resemblance to
Coccidæ and *Aleurodidæ* has given rise to great confusion.   It
has been described as belonging to three distinct families of
Rhynchota, and even in a recent number of the 'Gardeners'
Chronicle' it is still referred to the family *Coccidæ*, to which it
certainly does not belong.   At present in entomological litera-
ture it stands in three different genera, belonging to two different
classes of insects.   Seeing that so much confusion surrounds the
nomenclature and taxonomy, it will perhaps be well, before
discussing the points of biological interest, to give a brief
historical account of the literature.

HISTORY.

   This insect was first described by Boisduval in 1867 *, under
the provisional name of *Coccus ? lataniæ*.   He found it in Paris
on various palms belonging to the genus *Latania*; but as it is
only to be found in hothouses, he concludes it must be of exotic
origin, for it is killed by putting the host-plants into the open
air.   He is uncertain as to what family of insects it belongs, but
suggests that when the male is known it will probably become
the type of a new genus; provisionally he places it in his genus

* Ent. Horticle, p. 355, figs. 49, 50.

Coccus. He describes the colour and form of the several stages through which it passes, and states that it has been reported as doing damage to the young shoots of *Latania borbonica*, and as occurring in all its stages on the leaves of *L. rubra.* He sent it to M. Signoret, who concluded that it belonged to the ' Pentatomides,' " mais ayant remis cette année au mois d'avril à sa disposition des individus plus développés, il est revenu sur cette opinion ; aujourd'hui il ne serait pas éloigné de le regarder comme le premier état d'un genre nouveau voisin des *Aleurodes.* D'autant plus qu'un autre insecte analogue trouvé en Provence, sur le laurier-tin et que, tous les deux, nous avions pris pour une Coccide, lui a produit une *Aleurode* voisine de celle que l'on recontre sur le chélidoine."

The next year Signoret [*] described it at length in his monograph of *Aleurodidæ,* where he named it *Boisduvalia lataniæ,* though he had doubts as to its systematic position, being uncertain whether it belonged to the *Aphidæ* or *Coccidæ.* The male being unknown, Signoret suggested that it may be winged, and that its life may be short like that of the males of *Dorthesia* and of *Coccidæ.* His specimens came from the Isle of Bourbon, where they were living on *Latania.*

Four years later Signoret [†] again refers to this insect, in a letter from Venice, in which he says that he can now settle the vexed question as to its affinities. " En effet, M. Targioni-Tozzetti vient de démontrer que c'est un état particulier d'un Aphidien attaqué par des Grégarines ; il y a arrêt de développement et formation d'un état tout particulier. M. Targioni a eu la bonne fortune de suivre le développement normal de cet *Aphis* qui vit sur les *Lataniæ,* et il en donnera la description détaillée dans le Bulletin de la Société entomologique italienne." We may suppose that this idea was abandoned, for no record appears in the Bull. Soc. Ent. Ital. from 1872–1888 of any publications by Targioni-Tozzetti, or any other writer, on the subject.

An insect like this was described by Westwood [‡] in 1879 under the name of *Asterolecanium orchidearum,* " a new species of scale insect." He calls it the fimbriated or star-scale, and places it in the genus *Asterolecanium,* which had been erected by

[*] Ann. Soc. Ent. France, (4) viii. 1868, p. 400, pl. x. figs. 2, 2 A.

[†] Bull. Soc. Ent. France, (5) ii. 1872, p. xxx.

[‡] ' Gardeners' Chronicle,' ser. 2, xii. 1879, p. 796, fig. 131.

Targioni-Tozzetti. " One such species," he says, " was lately described in this work under the name of *Coccus stellifer*, and we are now enabled to figure another species, for a knowledge of which we are indebted to Mr. F. W. Burbidge, of the Botanical Garden of Trinity College, Dublin, by whom it was found in the Orchid-house, especially affecting the Ladyslippers (Cypripediums), but also occurring sparingly on Sobralias, Cattleyas, and Dendrobiums. Our engraving (fig. 131) represents two small leaves of a Cypripedium, showing that it is chiefly the plain underside, and not the spotted upperside of the leaves, that the insects attack, forming small groups. The natural size of the full-grown insects is shown upon the leaves (figs. 1, 2), and the magnified insect is seen at fig. 3, with a small portion of the waxy marginal scales at fig. 4. It will be seen from fig. 3 that all traces of articulation in the body are lost, and that the fimbriated margin is more or less incomplete in parts, and not so continuous as shown in fig. 4 . . . . . Fig. 5 represents the underside of a young specimen of one of the insects, copied from Dr. Signoret's plates, showing the articulation of the body, and the three pairs of jointed legs, which are gradually absorbed and lost after the insect has become affixed as a scale upon the surface of the leaf. The species may be termed *Asterolecanium orchidearum*, J. O. W. It closely resembles *A. bambusæ*, Sign. *, which is parasitic on the bamboo, but the scaly fimbriation is longer than in that species, the habitat also indicating it as distinct. The males of none of the species of the genus have yet been observed."

The insect under investigation was found to agree with the descriptions of *Cerataphis lataniæ* (see next page); and to be quite certain that the Cambridge species was the same as the one Westwood had received from Dublin in 1879, I wrote to Mr. Burbidge at the Trinity College Botanic Garden, who very kindly sent me some specimens : these proved to be identical with the species found in Cambridge. Mr. R. Newstead, to whom specimens were submitted, confirmed the identification of the insect as *Cerataphis lataniæ*. Professor Poulton has not been able to find any type of *A. orchidearum* in the Museum at Oxford.

Westwood's name of *Asterolecanium orchidearum* has never appeared in the ' Zoological Record,' or other lists, doubtless

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* Ann. Soc. Ent. France, 4ᵉ sér. x. (1870), pl. 8. fig. 3.

because he named and described it in the 'Gardeners' Chronicle,' which is not a zoological work.

In 1881 Signoret * having received the winged female of *Boisduvalia lataniæ*, realized that he had given the same name to two different genera. The name as applying to this insect he preserved on the ground of priority, for in this case it was given in 1868, while the name as applying to two *Coccidæ*, given in 1875 (*B. lauri* and *B.* 4-*caudata*), he changed to *Oudablis*.

The next year Lichtenstein † found the winged form, and changed the name to *Cerataphis lataniæ*, having determined that it is an Aphid. "L'insecte des *Latanias*, que Boisduval a nommé *Coccus lataniæ* et Signoret *Boisduvalia lataniæ*, est décidément un Aphidien du groupe des *Pemphigiens* et très voisin du genre *Vacuna* Heyden. J'ai enfin obtenu par élevage la forme ailée vivante. C'est un petit Puceron jaune clair à sa sortie de la nymphe, et, trois ou quatre jours après, devenant brun, à yeux noirs, qui a tout à fait l'apparence du *Phylloxera* et porte ses ailes à plat comme lui. La nervure cubitale des ailes supérieures est fourchue et les antennes ont cinq articles, caractères qui sont ceux du genre *Vacuna*. Mais la présence de deux petites cornes coniques et aiguës entre les antennes l'en distinguent et m'ont dicté le nom générique sous lequel je l'ai placé en collection; *Cerataphis lataniæ* Bois. (sub *Coccus*). Je ne puis conserver le nom de Signoret, parce qu'il a été donné sans *diagnose* et qu'il fait double emploi avec le genre *Boisduvalia* du même auteur, genre *Coccide* bien diagnosé." On p. xvi Lichtenstein refers the insect to his tribe Schizoneuriens, and this must at present be regarded as its scientific position. His remarks are best quoted fully for they are of signal importance :—

"Notre collègue M. Signoret a fait paraître dans le Bulletin no. 24 de 1881 une note relative à un insecte des serres, décrit pour la première fois par Boisduval dans son 'Entomologie agricole,' sous le nom de *Coccus lataniæ*, et après lui par M. Signoret sous celui de *Boisduvalia lataniæ*, dans sa Monographie des *Aleurodes*. Cet insecte n'est ni un *Coccidien* ni un *Aleurodien*, c'est un *Aphidien* fort curieux, dont je pourrai sous peu, je l'espère, présenter l'histoire complète de l'évolution.

"La forme ailée, très rare, le rapproche des *Schizoneura*, dont il

* Bull. Soc. Ent. France, 6e sér. i. 1881, p. clvii.
† *Op. cit.* (6) ii. 1882, p. lxxiv.

a les antennes courtes et annelées.   N'ayant pas pu encore le faire pondre, j'ignore si c'est une forme émigrante à petits à rostre, ou la forme pupifère à petits sexués sans rostre, ou enfin un mâle. La forme arrondie et frangées, qui est la plus commune, me paraît très voisine de celle du genre *Acanthochermes* de Kollar, dont le pourtour est orné également d'une frange élégante.

" Je l'ai mis en collection sous le nom de *Cerataphis lataniæ* [*] en attendant de donner la diagnose de toutes les formes, ce qui me paraît indispensable pour une bonne description d'un Aphidien.

"Comme tout le monde, et notre savant collègue lui-même, avait oublié qu'il y avait un genre *Boisduvalia* dans les *Aleurodes*, et que le même auteur l'a remis dans les *Coccides,* où il renferme trois espèces (*lauri* Boisd., 4-*caudata* Sign., *parietariæ* Licht.), ne vaudrait-il pas mieux considérer comme non avenue la description de cet *Aphidien* parmi les *Aleurodes,* où M. Signoret ne l'ajoute qu'à regret, et laisser *Boisduvalia* comme genre de *Coccides,* en attendant ma description, ou celle d'un collègue plus avancé que moi dans l'étude de l'insecte, pour mettre le *Cerataphis lataniæ* à la place qu'il devra occuper un jour entre les *Pamphigiens* et les Phylloxériens ? "

In a note in the same volume (p. xxxv) Signoret refers the species to the family *Aphidæ* without remarking on the changed position, merely stating that this species of Aphid is found on an orchid (*Cœlia albiflora*) and on many other plants.

The insect is next (1883) noticed by Buckton [†] in an Appendix to his ' British Aphides,' where he expresses himself doubtful as to its position.   He has found no male, and says only three specimens of the winged female have been recorded, and those were not taken in England.

Yet another synonym now exists, for in 1901, Hempel [‡] placed it in the genus *Ceratovacuna* as a n. sp. *brasiliensis*; it is met with on various species of palm at S. Paulo in Brazil, on a species of *Epidendron,* and also on *Cattleya harrisonia.*   Though he found winged and apterous females, he obtained no males.

The most recent reference to it is Jan. 15th, 1902, in the

[*] "*Cerataphis* à cause de deux petites cornes sur la tête *chez toutes les formes* que je connais jusqu'à présent; mais M. Signoret a vu aussi des Embryons sans cornes."

[†] British Aphides: Ray Society, 1883, p. 197.

[‡] Ann. & Mag. Nat. Hist. ser. 7, viii. p. 384.

' Gardeners' Chronicle,' where Westwood's figures are repro-
duced still under the name of *Asterolecanium orchidearum*.
Mr. Lynch, of the Cambridge Botanic Garden, who is interested
in the insect as being an inhabitant of the orchid-house, brought
to my notice this article, which led to my finding Westwood's
original description.

Thus it is seen that the creature has appeared under the names
of *Coccus?* *latania*, Boisd., *Boisduvalia latania*, Sign., *Asterole-
canium orchidearum*, Westw., *Cerataphis latania*, Licht., *Cerato-
vacuna brasiliensis*, Hemp. Of these the name of *Cerataphis
latania* must stand.

Synonymy of CERATAPHIS LATANIÆ.

Cerataphis, Lichtenstein (1882) : [Rhynchota, Fam. *Aphidida*,
Tribe *Schizoneuriens*].

Boisduvalia, Signoret (1868) ; [nec *Boisduvalia*, Desv. 1830 ;
nec *Boisduvalia*, Montre. 1855; nec *Boisduvalia*, Sign. 1875].

latania (*Coccus?*), Boisduval, 1867, Ent. Horticole, p. 355, figs. 49,
50 (ascribed to *Coccida*).

latania (*Boisduvalia*), Signoret, 1868, Ann. Soc. Ent. France, (4)
viii. p. 400, pl. x. figs. 2, 2 A [young] (ascribed to *Aleurodida*).

orchidearum (*Asterolecanium*), Westwood, 1879, Gardeners'
Chronicle, ser. 2, xii. p. 796, fig. 131 (ascribed to *Coccida*) ;
new synonym.

latania (*Cerataphis*), Lichtenstein, 1882, Bull. Soc. Ent. France,
(6) ii. pp. xvi & lxxiv (ascribed to *Aphida*, tribe *Schizo-
neuriens*).

latania (*Cerataphis*), Buckton, 1883, Ray Society, Mon. Brit.
Aphides, iv. p. 198, pl. 134 (ascribed to *Aphida*).

brasiliensis (*Ceratovacuna*), Hempel, 1901, Ann. & Mag. Nat.
Hist. ser. 7, viii. p. 384 (ascribed to *Aphida*) ; new synonym.

orchidearum (*Asterolecanium*), Gardeners' Chronicle, ser. 3, xxxi.
Jan. 25th, 1902, p. 57 (ascribed to *Coccida*).

BIOLOGY.

In turning to the natural history of this interesting species it
is, perhaps, not out of place to briefly summarize the facts that
are known at present. The species occurs frequently in orchid-
houses in Britain, as the apterous parthenogenetic form; and for

one or more years about 1879, Mr. G. S. Saunders noticed the winged adult female in an orchid-house at Bristol; he has kindly given me a note on the subject, which will be found on p. 105, at the end of this memoir. In Brazil the winged female form is apparently not uncommon (cf. *Ceratovacuna brasiliensis*, Hempel, and is met with as a very rare occurrence on the continent of Europe—so far only three specimens have been recorded. No male has been discovered anywhere. On the Continent the apterous female is well known in hothouses, living on various species of palms and orchids. With us it always occurs on orchids, and has been reported from several localities— I have received it from Dublin, where it has been known for many years; and also from Cambridge. At Kew it is, I find, recognized as an orchid parasite, but I could get no specimens from the houses there.

Up to the present (and apart from the recently recorded Brazilian form which we know only by description), only three individuals of the winged form have ever been obtained, and they are all females. Buckton [*], in 1883, says the imago of this viviparous winged female is apparently very rare, " for only three mutilated specimens are at present known. It has not yet been taken in England."

As regards this Brazilian form, which Hempel [†] described last year under the name of *Ceratovacuna brasiliensis*, n. sp., it is, as already stated, another synonym for *Cerataphis lataniæ*, an opinion confirmed by Mr. R. Newstead. Hempel has found no males, but describes, not only the adult apterous female, but also the larval and adult winged female. This is important evidence as showing that in its native countries this species does not permanently remain in the form in which it is found with us, and as shown in Plate **12**. It forms conspicuous groups or colonies on leaves and flower-stems of *Cypripedium* and other orchids, and can be procured all the year round. The colonies consist of individuals of all ages, from the small pale yellow young which actively wander about, to the round black immotile adults with their characteristic halo of white wax. The youngest forms, measuring about 5 mm. (or less) in length, are free from this fringe of wax; the pair of dark eyes, situated anteriorly near the

[*] British Aphides, Ray Society, 1883.
[†] Ann. & Mag. Nat. Hist. ser. 7, viii. (1901) p. 384.

edge of the body, are easily seen because the general colour of the creature is pale yellow. In this condition they move about freely on the plant, but their wanderings are not very extensive, and, in a state of nature, the species could scarcely rely on these young forms as the sole means of dissemination. In their native countries this probably is effected by the winged forms. Later on the early form becomes covered with a powdery white secretion, but still there is no definite ring round the margin of the body such as marks the older stages.

In the active or locomotive early form the antennæ are rather stout and blunt; they are composed of a basal joint and four segments, of which the last is the longest (Pl. 12. fig. 4); at its tip it carries several setæ and a hook or claw, and there are, in addition, one or two setæ on each of the other segments. The last three joints of the antennæ are ringed (Pl. 12. figs. 3, 5). Between the antennæ, on the front of the head, are two small horns in all the specimens I have seen, and in all forms according to Hempel and Lichtenstein; but Signoret * states that in some young there are no traces of these horns, and suggests that this may be a sexual difference †. In this early condition the body is elongated and the dorsum is but slightly convex; the head and thorax make up almost one-half of the length of the body, being clearly marked off from the abdomen by a groove; the articulation of the body is very obvious at this stage. The legs are not yet hidden by the marginal waxy secretion, which makes its appearance later. The tarsi are two-jointed, and are armed with setæ, and end with two strong recurved bristles or claws; all the segments bear scattered setæ, and in all respects are formed normally as in *Aphis*. The rostrum is proportionately longer in this stage than it is in the adult, for it reaches beyond the posterior coxæ; the basal section is bulbous, and the third and terminal joint is pointed; each of the first two parts bears a pair of setæ, while the third, or last, is provided with two pairs.

This form is succeeded by one of an ochreous green colour, larger in size, and in which the body has developed, round the margin, the ring of tubercles from which, later, the fringe of

* Ann. Soc. Ent. France, 4ᵉ sér. viii. (1868) p. 400.
† See footnote, p. 94.

wax is secreted. The eyes are still conspicuous as dark red-brown spots. The body, still powdered over with a fine white dust which soon disappears, is broader than in the preceding stage and is less flattened. The antennæ and legs are unchanged; the head is less pointed, and the rostrum ends between the second and third legs.

As the adult condition is approached the activity becomes less, while the colour deepens and the body becomes more round in outline and more arched dorsally The adult insect (Pl. 12. fig. 2), like a Coccid, is fixed by the suctorial proboscis to the host plant, and appears as a dark, almost black, rounded excrescence, surrounded by a conspicuous fringe of white wax; it is about 1·50 mm. in length and 1·25 mm. in width: the antennæ are about ·23 mm. in length, but are usually hidden by the border of wax. Across the dorsal surface, about halfway back, is a deep furrow, caused by the articulation becoming more marked in these two segments, separating the thorax from the abdomen, and so the insect has the appearance of being, to some extent, divided across the middle. Dorsally, in the posterior region of the body, are two cornicles as shown in figs. 7–9. The eyes are now inconspicuous.

The confusion that has grown up in the literature relating to this insect has been due, as I have already stated, to the fact that it closely resembles many *Coccidæ* and *Aleurodidæ*. The three great families of these insects—*Coccidæ*, *Aleurodidæ*, *Aphidæ*—have, so far as outward appearance goes, much in common, and systematically the members of these families are distinguished from one another by such minor points as differences in the number of joints in the feet and antennæ. But the real distinctions are biological, occurring in the life-histories— the *Coccidæ* going through a complex metamorphosis which is totally different in the two sexes, resulting in the production of imagoes where the two sexes differ completely. The *Aleurodidæ*, though they show a remarkable series of metamorphoses, are identical in the two sexes, and these are constantly produced in each generation, the development resulting in the production of the normal Hemipterous form, alike for male and female. The *Aphidæ*, on the other hand, exhibit a very different and striking series of changes, the unique feature of which is that the development is, so to speak, spread over a number of successive

generations, resulting in the production of a winged sexual form in cases where winged individuals have previously occurred in the cycle of generations. The life-history of *Cerataphis lataniæ* is very different from that of the *Coccidæ*.

This insect has now been under observation for more than a year in Cambridge, and though the investigation has been of a somewhat desultory nature, owing to the lack of a special laboratory in which to pursue such work, yet nothing has been found to suggest in any way that the conditions of form and development mentioned above have been departed from by any individuals. Specimens have been collected from time to time by Miss M. A. Sharp and myself, and submitted to examination with a view to ascertaining whether any diversity, other than that of age, could be detected among them, but we have failed to find any indication of such diversity. Moreover, all figures and records that exist of the insects in this country exhibit it in this form only. Westwood's figures of the specimens obtained from Dublin in 1879 show the young and adult forms as we have them now at Cambridge. Buckton's figures and remarks give evidence of the same uniformity.

All the observations, then, that have been made in this country lead to the belief that the species exhibits here only one form which reproduces parthenogenetically in an uninterrupted manner. Parthenogenesis extending over a variable number of generations is, of course, a very common occurrence among *Aphidæ*; and it is probable that even in climates (such as the Isle of Bourbon, Brazil, &c.) where the winged females of this species are produced not infrequently, that it is still an important, if not an exclusive, mode of perpetuating the species. No males have yet been discovered anywhere. Remarkable as this fact is, it is not without parallel, but it is extremely unusual for this mode of reproduction to be the concomitant of a metamorphotic ontogeny repeated uninterruptedly from generation to generation. It is possible that the parthenogenetic reproduction of *Aphidæ* can be carried on for a great number of generations; indeed, such continuity has been shown to exist, though its limits have not yet been determined.

Cerataphis lataniæ in this country appears to be entirely deprived of the complex life-history found in its allies (on which I shall subsequently enlarge). In the Cambridge Natural

History * Dr. Sharp says :—" The simple form of Aphid life may be described as follows :—Eggs are laid in the autumn and hatch in the spring, giving rise to females of an imperfect character having no wings ; these produce living young partheno-genetically, and this process may be repeated for a few or for many generations, and there may be in these generations a greater or less number of winged individuals, and perhaps a few males. After a time when temperature falls, or when the supply of food is less in quantity, or after a period of deliberate abstention from food, sexual individuals are produced, and fertilized eggs are laid which hatch in the spring, and the phenomena are repeated.   In other cases these phenomena are added to or rendered more complicated by the intercalated parthenogenetic generations exhibiting well-marked metamorphosis, of kinds such as occur in apterous or winged insects ; while again the habits of successive generations may differ greatly, the individuals of some genera-tions dwelling in galls, while those of other generations live underground on roots."

It being taken for granted that *Cerataphis lataniæ* as found in Britain is an Aphid, although it departs biologically very widely from that group of Insects, inasmuch as it appears to be totally deprived of those successional metamorphoses that are so characteristic of *Aphidæ*, it becomes interesting to inquire how this arises.   In order to make my ideas on this point comprehensible it is advisable briefly to summarize Pergande's † recent remarkable discoveries as to the life-histories of migratory Aphides.   Although the results are only lately published, he has been prosecuting this inquiry for more than 20 years.   The simplest form of Aphid-life is that described by Dr. Sharp, and quoted above, while the most complex is that described by Pergande.   He shows that these migratory Aphides exhibit the most complex form, not merely of ontogenesis, but also of the cycles of generations that are so marvellous in this family.   He has discovered that these creatures possess, in their ontogeny, an " aleurodiform " stage, to which our hothouse inhabitant bears a most striking resemblance.   The allied forms which Pergande studied are *Hormaphis hamamelidis*, Fitch, and *Hamamelistes*

* Insects, part ii. p. 582.

† U.S. Dep. Agric., Ent. 1901, no. 9.   " The Life-history of two Species of Plant-lice, inhabiting both the Witch-hazel and Birch."

spinosus, Shimer, Aphids that make galls on the leaves of the witch-hazel (*Hamamelis virginiana*) in North America. The individuals in the gall pass through a metamorphosis, appearing in a different form after each ecdysis. The individuals of this generation are not winged, but remain on the host plant, and produce a second generation within the walls of the gall. The individuals of this generation also undergo their development and metamorphosis inside the gall, but they differ essentially from those of the first generation inasmuch as they develop wings and all ultimately leave the shelter of the gall.

From the witch-hazel these winged forms migrate to the birch (*Betula nigra*), where they immediately place their young, so that the species now lives not in galls but exposed on birch-leaves. This third generation undergoes a complex metamorphosis, the successive instars being very different from one another; the last instar so closely resembles many *Aleurodidæ*, that Pergande has called it the "aleurodiform" stage. In calling it "aleurodiform" it may be as well to remark here that it is the young *Aleurodes* which the Aphis resembles, and not the adult form.

While living on the birch, two other aleurodiform generations (*i. e.* the fourth and fifth) are passed through, but they differ only very slightly from the third.

The sixth generation is remarkably different. In this generation the insect is winged and leaves the birch to return to the hazel. It may safely be taken for granted that hitherto all the individuals produced have been females, but a seventh generation arises in which both sexes occur. Eggs are laid before the leaves appear in the spring, the young hatching from these eggs start the galls, and the life-cycle is begun once more.

From this work by Pergande it will be seen that *Cerataphis lataniæ* found on orchids corresponds to the aleurodiform stage of a migratory Aphis, such as he has described in the case of *Hormaphis hamamelidis* and its ally. In these insects, however, the stage is transitory, and is usually succeeded by a winged form; but in the case of *Cerataphis* in Britain, it seems that no further stage is reached. So far as the observations in Cambridge go, they lead us to believe that this aleurodiform stage is the permanent condition of the insect; in spite of the

fact that no males * have been found, yet in the colonies there are always young forms: thus the reproduction as carried on in this country must be solely parthenogenetic, and since the creature is not in the true imago condition, it is a sort of pædogenesis as well as parthenogenesis. Possibly this condition results from the fact that the creatures live in hothouses where the climatic conditions are constant and the food-supply uniform, whereas in a state of nature one or both of these factors might be varied. If these natural conditions could be imitated, we should perhaps succeed in getting other generations to follow on this aleurodiform stage. In the case of *Hormaphis hamamelidis*, the generation which leaves the gall does so on account of the food becoming used up. The *Cerataphis* on orchids in our greenhouses does not experience this, for the food-supply is fairly constant, and also the atmospheric environment: thus it seems probable there is no incentive to produce the winged form.

Our insect, therefore, is seen to exhibit the simple condition of life-cycles as described by Dr. Sharp, while its ontogenetic and morphological form is that which occurs as part of the complex series of generations so lucidly depicted by Pergande. These facts lead to the supposition that it is one of the migratory Aphides that has been deprived of the series of metamorphoses, owing to an artificial mode of life.

When Huxley studied Aphides, the remarkable phenomena that he met with so impressed him that he devoted considerable attention to their bearing on the questions of individuality and the individual in Biology. Since then, the discoveries that have been made in this group of Insects have rendered the

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* Signoret's suggestion that the differences he observed in the larvæ may be sexual, is probably incorrect, if we may judge from the life-histories of the species described by Pergande. In the latter, the sexual forms are produced in a special final generation, quite distinct from the preceding generations of parthenogenetic individuals. The larvæ that Signoret thought might be males (differing from the others mainly in possessing no frontal horns) occurred indiscriminately, and not in a special sexual generation, as described by Pergande. It is probable that those Signoret states as being without horns were merely very early larvæ in which these organs were not yet fully developed; I have often found in very young individuals that the horns are almost undiscernible.

problem still more complicated and difficult. Huxley [*] says:
" Every organized being *has* been formless and will again be
formless ; the individual animal or plant is the *sum* of the
incessant changes which succeed one another between these
two periods of rest." . . . . . . [the individual] " is the sum of
the phenomena presented by a single life : in other words, it is
all those animal forms which proceed from a single egg taken
together."

Herbert Spencer, however, holds a totally different view
from that which Huxley formulated. His opinion is given in
the chapter on " Individuality " in the first edition of the
' Principles of Biology,' written in 1864. Admitting the many
difficulties which surround the subject, he proceeds to discuss
the validity of the theory that the whole product of a single
fertilized germ shall be regarded as the true individual, whether
such whole product be organized as one or many masses that
are partially or completely separate. He thinks this is an
undesirable definition, for it involves the application of the
word individual to numerous separate living bodies, a meaning
strikingly in conflict with the ordinary conception of the word.
As an example of this he instances the case of *Aphidæ*, " where
the organism is but an infinitesimal part of the germ-product ;
and yet has that completeness required for sexual reproduc-
tion . . . . . . [If the individual is constituted by the whole
germ-product, whether continuously or discontinuously de-
veloped, then, not only must individuality be denied to each
of the imperfect *Aphides*, but also to each of the perfect males
and females ; since no one of them is more than a minute
fraction of the total germ-product] " [†]. As he cannot therefore
adopt this view, he endeavours to " make the best practicable
compromise," with the knowledge that there is no definition of
individuality which is unobjectionable. The essential idea of the
conception of individuality he takes to be union among parts of
the object and separateness from other objects ; it also involves
the manifestation of Life, which he regards as " the definite
combination of heterogeneous changes, both simultaneous and

* Scientific Memoirs of Thomas Henry Huxley, i. p. 147. London, 1898.
(The date of the original paper is 1852.)

† This sentence is omitted in the 1898 edition.

successive, in correspondence with external co-existences and sequences." A biological individual is therefore one which possesses the power to live alone, given suitable conditions, and which is a wholly or partially independent organized mass, arising continuously or discontinuously: "we must accord the title to each separate aphis, each polype of a polypedom . . . ." There are anomalies, which he regards as inevitable, if the hypothesis of Evolution is correct, for organic forms must have arisen by insensible gradations; but he concludes the chapter by saying: "We must be content with a course which commits us to the smallest number of incongruities; and this course is, to consider as an individual, any organized mass [centre or axis]* that is capable of independently carrying on that continuous adjustment of inner to outer relations which constitutes Life."

Since the period at which Huxley and Spencer wrote, our knowledge of the cycles of generations in *Aphidæ* has become more extended, and the life-histories have been found in many cases to be extremely complex. As has been stated above, in the case of *Cerataphis lataniæ* in this country, the species is apparently maintained permanently by parthenogenetic pædo-genesis of an aleurodiform instar. According to Huxley's view, we must consider all the specimens co-existent in different parts of this country, and those of all past generations that have presented the same phenomena, as a single individual.

It is well known to modern zoologists that there exists a great variety of individuals, individualities, and individual lives; and Spencer's definition is clearly more convenient practically than Huxley's, though it conveys no connotation of this variety.

The permanent, or quasi-permanent, condition of *Cerataphis lataniæ* in this country lends additional support to the view, at present accepted very widely, that in polymorphic insects the particular form attained by an individual is determined by the food. In *Hormaphis hamamelidis* the form is altered when the food becomes inadequate, and recourse is had to living on the leaves of another tree. On this the aleurodiform generations are maintained till the nutriment fails in the autumn, when winged forms are again produced. As the conditions under

* Omitted in 1898 edition.

which *Cerataphis lataniæ* lives in our hothouses are, roughly speaking, constant, especially as regards an equable supply of nutriment, we may conjecture that this is responsible for the permanence of the aleurodiform stage. Whether the form of the creature can be altered by interference with its food-supply is a very interesting subject for experiment. From this point of view it is of great importance that the converse experiments should be made on *Hormaphis*, or on some other migratory Aphis, with a view to ascertaining whether, by supplying successive generations with a constant supply of food under equable conditions of temperature, &c., the creature could be maintained for many generations, or permanently, in the aleurodiform stage.

Another factor, beyond the constant conditions of food and temperature, that may increase the tendency to the stability of this transitory form, may perhaps be found in its partheno-genetic reproduction ; for it has been pointed out that parthenogenesis in Insecta is very commonly concomitant with the production of young that are all of one sex.

I am well aware of the incompleteness and inadequacy of the views expressed in this paper, but if this communication shall lead to experiments being instituted with this creature, then my object will be attained.

APPENDIX.

As stated on p. 95, when this paper was read, Mr. G. S. Saunders made some suggestions on the subject, the most important of which was that in 1879 he observed the winged female. With his permission I append his remarks :—" I was staying with an uncle of mine at Clifton near Bristol, who had a large collection of orchids, in May 1879, when I found this insect in considerable numbers on the leaves of various orchids, but most commonly on Cypripediums. Knowing very little at that time about insects of this nature, I took the apterous females for one of the *Coccidæ*, and I found a short account of the insect in Boisduval's 'Essai sur l'Entomologie Horticole.' One day I was surprised to find some of the larvæ had become pupæ ; later on I found the females, which I then took for males, and finding that Boisduval stated that the males were un-known, I wrote to Signoret stating that I had found the males.

I forget if I sent him specimens or only described the insect : he replied that what I had found were probably females. I found these winged females were not nearly so common as the apterous ones, still at various times I must have found a hundred or so. I think I noticed this insect in its different conditions two or three years, and then my uncle got a new head-gardener and *Cerataphis* vanished, and I saw it no more."

Mr. Saunders also kindly sent me some drawings made in 1879 of the winged female, and some details of structure, similar to those that have already appeared in Buckton's work : in addition there are also some figures of the nymphal condition, one of which I have added to Plate **12** (fig. 6) as no previous illustration of this instar has been published.

On March 11th, 1903, Mr. Saunders wrote to say that "On carefully examining some dried specimens of *Cerataphis lataniæ* which I had mounted on card, I noticed what I do not think had ever been discovered before, that the apterous female has cornicles ; Buckton has not noticed them evidently. You do not show them in your drawing, and I certainly never saw them in the specimens I examined when fresh. I have just made a drawing under the camera lucida, which I enclose with my other drawings." I find this discovery of Mr. Saunders is correct, and I have added sketches of the cornicles as they exist in the adult (Pl. **12**. figs. 7–9). Neither Mr. Saunders nor I have found them in the young larvæ; he says " they are not in the winged forms, but are present in the pupæ."

The occurrence of the winged female in England for one or more seasons twenty-four years ago is of considerable interest in connection with the peculiar life-cycle of this creature, and, on the whole, lends, it appears to me, additional support to the view I suggest, viz., that the extent of life-cycle, or the number and variety of the instars that go to make up the life-history of this creature, are determined by the conditions under which they live.

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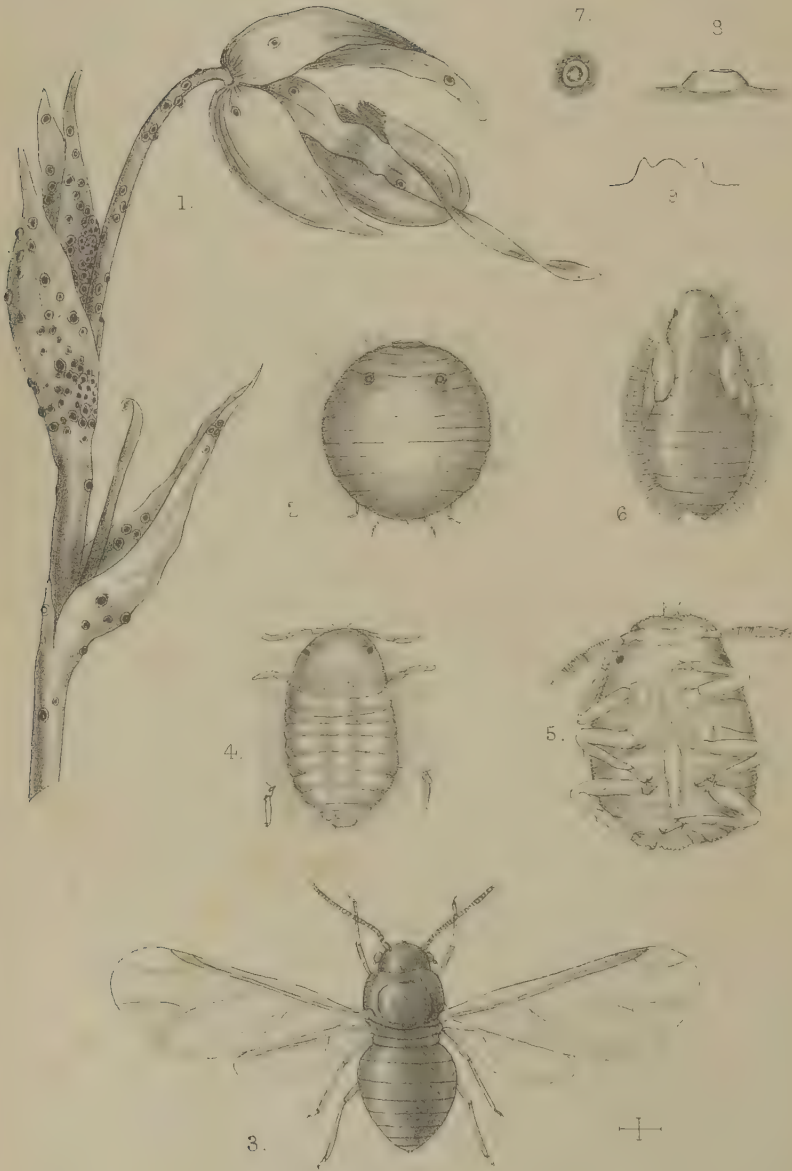
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EXPLANATION OF PLATE 12.

Fig. 1. *Cypripedium* with *Cerataphis lataniæ* 'in situ'; natural size.

    2. Dorsal view of adult, showing the cornicles. Length = 1·5 mm., width = 1·25 mm. (By an oversight, this figure is inverted.)

    3. Winged female (by G. S. Saunders).

    4. Dorsal view of larva in which the fringe of wax has developed.

    5. Enlarged view of same from the ventral surface, showing the proboscis, ringed antennæ, frontal horns, &c. Length = ·55 mm., width = ·4 mm., length of antennæ = ·25 mm.

    6. Pupa of the winged female (by G. S. Saunders).

    7, 8, 9. Cornicle : (*a*) from above, (*b*) from the side, (*c*) in section. (By G. S. Saunders.)

Observations on Freshwater Rhizopods, with some Remarks on their Classification. By G. S. WEST, M.A., F.L.S., Professor of Natural History at the Royal Agricultural College, Cirencester.

[Read 16th April, 1903.]

(PLATE 13.)

SINCE my first communication to the Linnean Society on the subject of freshwater Rhizopods, in 1901, I have had the opportunity of examining a considerable amount of material from some of the outlying districts of the British Isles, and several animals of this class have come under my notice concerning which I can find no previous mention. Two of these are undescribed species of the genus *Hyalosphenia*, one is a species of *Sphenoderia* with a prettily constructed shell, and another is a strange nude form referable to Cienkowski's genus *Nuclearia*.

Rhizopods are almost cosmopolitan in their distribution, and few animals exhibit a wider range of variation. In many cases it is almost impossible to define clearly their specific differences, and little attention has been given in the past to the study of the variation of the more abundant forms.

Altitude appears to have little effect on most species of Rhizopods, as they occur in abundance in suitable localities up to several thousands of feet above the sea-level. Leidy * has collected them at 10,000 ft. in the Uinta Mountains; and I have observed *Trinema enchelys* in collections from the Chilian Andes at 11,000 ft. There is apparently no restriction of special forms to alpine or subalpine situations †, although a few species, such as *Assulina seminulum* and *Heleopera petricola*, are most frequent in elevated districts, and a few others seem to have a preference for low-lying ponds and ditches.

In examining a large number of collections from the West of Scotland, it was noticed that Rhizopods were relatively less abundant in the Outer Hebrides than on the mainland of Sutherland and Inverness. As the collections numbered more than 500, and were fairly representative, this feature, although

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* Leidy, Freshw. Rhiz. N. Amer. 1879, p. 13.

† This is also fairly evident from the lists of alpine and subalpine Rhizopods recorded from Sweden and Finland by Lagerheim. *Cf.* Geol. Fören. Förhandl 1902, Bd. xxiii. Häft. 6, no. 209, pp. 471–472.

possibly quite accidental, is deserving of notice. The following species were observed from the Outer Hebrides :—

From Lewis :—*Nuclearia conspicua, Amœba proteus, Cochliopodium bilimbosum, Arcella vulgaris* and var. *gibbosa, Centropyxis aculeata, Difflugia constricta, D. pyriformis, D. acuminata, D. Solowetzkii, D. corona, D. globulosa, Nebela collaris, N. flabellulum, N. carinata, Heleopera petricola, Quadrula symmetrica, Euglypha alveolata, E. ciliata, Sphenoderia lenta, Assulina seminulum, Trinema enchelys, Cyphoderia ampullacea.*

From Harris :— *Vampyrella lateritia, Pelomyxa palustris, Amœba verrucosa, Dactylosphærium radiosum, Cochliopodium bilimbosum, Arcella vulgaris, A. discoides, Centropyxis aculeata, Difflugia pyriformis, D. globulosa, Nebela flabellulum, Quadrula symmetrica, Hyalosphenia platystoma, Euglypha alveolata, E. ciliata, E. cristata, Trinema enchelys, Pamphagus hyalinus.*

From North Uist:—*Dactylosphærium radiosum, Arcella vulgaris, Centropyxis aculeata, Difflugia pyriformis, D. acuminata, E. globulosa, Nebela collaris, Trinema enchelys, Euglypha ciliata, Quadrula symmetrica.*

From South Uist:—*Amœba verrucosa, Dactylosphærium radiosum, Arcella vulgaris* and var. *gibbosa, Centropyxis aculeata, Difflugia constricta, D. pyriformis, D. acuminata, Nebela collaris, Euglypha ciliata, Sphenoderia lenta, Trinema enchelys.*

From Benbecula:—*Amœba proteus, Arcella vulgaris, Difflugia globulosa, D. pyriformis, Euglypha alveolata, E. ciliata, Trinema enchelys.*

The two following species were collected on St. Mary's, Scilly Islands, and add to the distribution of British Rhizopods :— *Amœba verrucosa* and *Difflugia globulosa.*

The systematic position of *Vampyrella* and allied genera has long been a matter of considerable doubt. It seems clear that the two genera *Vampyrella* and *Nuclearia* are very closely allied, on account of their structure and the nature of their pseudopodia, even though the latter genus does not possess the curious red pigment found in the protoplasm of *Vampyrella.* It seems equally clear that they can hardly be retained in Lankester's ' Proteomyxa,' a group instituted to include a number of genera concerning which more information was required. The long pseudopodia of *Vampyrella* are straight, often radiating, and always considerably attenuated towards a fine apex; they are frequently branched, and the branching takes place almost

invariably near their broad bases. The same is true of Cien-kowski's *Nuclearia*; but in several other genera which were included in the 'Proteomyxa,' such as *Protomyxa*, Haeckel, and *Biomyxa*, Leidy, the pseudopodia are anastomosing and often very irregular; they are bent and of variable width, exhibiting none of the rigidity shown by the straighter pseudopodia of *Vampyrella* or *Nuclearia*. The entire animals can be likened unto a *Gromia* without its shell, whereas such is not the case in *Vampyrella* or *Nuclearia*.

The nuclei of the different forms of Rhizopods are very similar and exhibit little variation in structure. The characters of the nucleus are to my mind of much less importance in these animals than might at first be imagined, and are of little classificatory value. It is difficult to see how such a uniformity of character as is exhibited by the nuclei of Rhizopods could be utilized as a basis of classification. The nucleus may also be absent in some species of a genus, although present in others (cf. *Cochliopodium minutum*).

Considering the foregoing facts, it appears advisable to remove the two genera *Vampyrella* and *Nuclearia* from the 'Proteomyxa,' chiefly on account of the nature of their pseudopodia, and place them in a separate order of the class Rhizopoda—the order 'Vampyrellida'[*]. By the establishment of this order the freshwater Rhizopods fall under four orders, which are characterized as follows:—

Order 1. **Proteomyxa.** Nude Rhizopods which in the amœboid condition possess an irregular mass of body-protoplasm, often reticulate, and anastoming pseudopodia of considerable irregularity.

e. g. *Biomyxa*, Leidy; *Gymnophrys*, Cienk.

Order 2. **Vampyrellida.** Nude Rhizopods which in the amœboid condition possess a body-protoplasm of more or less definite form, frequently globular or often elongated; with straight attenuated pseudopodia, often branched at the base.

e. g. *Vampyrella*, Cienk. (incl. *Leptophrys*, Hertwig and Lesser); *Nuclearia*, Cienk. (incl. *Heliophrys*, Greeff).

[*] *Cf.* G. S. West, "Some British Freshw. Rhiz. and Heliozoa," Journ. Linn. Soc., Zool. xxviii. 1901, pp. 308 & 333.

Order 3. **Amœbœa.** Nude Rhizopods which in the amœboid condition possess a very irregular mass of body-protoplasm; pseudopodia lobose, varying in form from mere undulations of the surface to elongate blunt processes (rarely attenuated and acute), sometimes branched, but never reticulate.

> e. g. *Amœba*, Ehrenb., *Pelomyxa*, Greeff, *Dactylosphœrium*, Hertwig & Lesser.

Order 4. **Testacea.** Rhizopods in which the body-protoplasm is enclosed in a shell of variable construction; pseudopodia blunt and lobose or thread-like and attenuated to fine points, often branched and rarely reticulate.

> e. g. *Difflugia*, Leclerc, *Arcella*, Ehrenb., *Euglypha*, Dujardin, *Pamphagus*, Bailey, *Diplophrys*, Barker, &c., &c.

The following is a systematic account of some of the most interesting Rhizopods I have recently examined.

Class RHIZOPODA.

Order **Vampyrellida.**

Genus NUCLEARIA, *Cienkowski.*

1. NUCLEARIA CONSPICUA, sp. n. (Pl. **13**. figs. 16-19.)

Protoplasmic body subglobose or angularly rounded; protoplasm undifferentiated, granulose, containing numerous large vacuoles, with a single large spherical nucleus which exhibits a punctate appearance; pseudopodia fairly numerous, stout, rigid, generally with one or two branches which are a little divergent and attenuated to fine points.

Diameter of body 83–120 μ; length of pseudopodia 17–54 μ.

Hab. In boggy pools, Lewis, Outer Hebrides.

This Rhizopod occurred in considerable profusion amongst numerous Desmids and other Algæ in small pools. The animals are of much larger size than *N. delicatula*, Cienk., or *N. simplex*, Cienk., and the protoplasm is much more vacuolated. There is a single nucleus present in each individual, but no contractile vacuoles were observed. The pseudopodia are protruded irregularly from the surface of the body-protoplasm, often in small clusters. They are broad at the base, generally straight and

much attenuated, and almost always branched. Except for their perfectly smooth exterior and absence of granules, they are very like those present in the genus *Vampyrella*.

This species is a voracious feeder, and many of the individuals were gorged with Desmids. The protoplasm contained no green colouring-matter, the chlorophyll of the Desmids disappearing very soon after ingestion. The pseudopodia were frequently entirely retracted, the animals then remaining in a quiescent state for a long time (fig. 18). In this state they much resembled the quiescent stages of *Vampyrella pedata*, Klein, but could be distinguished by the numerous vacuoles and the absence of the red pigment.

Slight stimulation of the animals, either mechanical or with reagents, caused a contraction of the pseudopodia, so that they became undulated, as shown in fig. 19.

I have previously pointed out that *Heterophrys varians*, Schulze, is identical with *Heliophrys variabilis*, Greeff, and that the animals in question do not belong to Archer's genus *Heterophrys*. I am now quite convinced that both are forms of Cienkowski's *Nuclearia delicatula*, and are Rhizopods which should be placed in the order ·Vampyrellida.

Genus VAMPYRELLA, *Cienkowski*.

2. VAMPYRELLA LATERITIA, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 253, pl. 45. figs. 10–16.—Amœba lateritia, *Fresenius*, 1856–8.—Vampyrella Spirogyræ, *Cienk. in Archiv für mikr. Anat.* i. 1865, p. 218, pls. 12–13. figs. 44–56.

Hab. West of Tarbert, Harris, Outer Hebrides.

Numerous examples were observed amongst various algæ, but all of them were sluggish, and none were observed feeding.

Order Amœbœa.

Family LOBOSA.

Genus PELOMYXA, *Greeff*.

3. PELOMYXA PALUSTRIS, *Greeff, in Archiv für mikr. Anat.* x. 1870, pp. 51–72, pls. 3–4.

Hab. Near Tarbert, Harris, Outer Hebrides.

Not uncommon in boggy pools amongst submerged *Sphagnum*.

Genus DACTYLOSPHÆRIUM, *Hertwig & Lesser.*

4. DACTYLOSPHÆRIUM RADIOSUM, *Blochmann, Die mikr. Thier-welt des Süsswass.,* I. *Protozoa* (Hamburg, 1895), p. 14.—Amœba radiosa, *Ehrenb.*

Hab. Gortahork, Co. Donegal, Ireland.

From the above locality a number of curious forms of this Rhizopod were observed in which the pseudopodia were distinctly twisted (fig. 2). This was not merely the condition of one or two pseudopodia of a single individual, but was general among the majority of the specimens. The condition was not brought about by any specially applied stimulation, and, although the pseudopodia exhibited slow movements, they made no attempt to unwind themselves. The same state was noticed and figured by Penard (in Mém. Soc. Phys. et d'Hist. Nat. Genève, tom. xxxi. no. 2, 1890, pl. 2. fig. 75) from Wiesbaden.

Diameter of body 16–19 μ; length of pseudopodia 23–46 μ.

Order **Testacea.**

Family ARCELLINA.

Genus DIFFLUGIA, *Leclerc.*

5. DIFFLUGIA ACUMINATA, *Ehrenb. Infus.* 1838, p. 131, pl. 9. fig. 3 ; *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 109, pl. 13.

Var. AMPHORA, *G. S. West, in Journ. Linn. Soc., Zool.* xxviii. (1901), p. 319.—D. amphora, *Penard, in Mém. Soc. Phys. et d'Hist. Nat. Genève,* tom. xxxi. no. 2, 1890, p. 139, pl. 13. figs. 55–65.

Some strange forms of this variety were observed from Y Foel Fras, N. Wales, in which large numbers of the empty cells of *Chlorobotrys regularis,* Bohlin, were incorporated with the shell. They were certainly the most extraordinary Rhizopod-shells I have ever examined. The cells of the alga are globular and the cell-walls are siliceous, and the entire shell of the *Difflugia* appeared to be built up of an accumulation of the empty cells of the unicellular alga. Length of shells 260–290 μ.

6. DIFFLUGIA SOLOWETZKII, *Mereschk.* ; *Levander,* ' *Material zur Kenntniss der Wasserfauna in der Umgebung von Helsingfors,*' *Acta Soc. pr. Fauna et Flora Fennicæ,* xii. no. 2, 1894, p. 18,

pl. 1. fig. 13.—D. elegans, *Penard, l. c.* p. 140, pl. 4. figs. 4–11.—
D. acuminata, *Ehrenb.*, var. elegans, *G. S. West, in Journ. Linn.
Soc., Zool.* xxviii. (1901) p. 319, pl. 28. figs. 11–12.

Hab. Rhiconich, Sutherland.

It seems probable that this *Difflugia* retains its characters
sufficiently well to be regarded in the light of a species. The
attenuated apex is always bent at a considerable angle from the
longitudinal axis and is invariably perforated. The size of the
shell is also much less than the average size of *D. acuminata*,
Ehrenb.

Genus NEBELA, *Leidy.*

7. NEBELA DENTISTOMA, *Penard, l. c.* p. 162, pl. 6. figs. 98–100;
pl. 7. figs. 1–5.—*G. S. West, in Journ. Linn. Soc., Zool.* xxviii.
(1901) p. 322.—N. crenulata, *Cash.*

Hab. Lund's Fell, N. Yorkshire; amongst mosses.

Genus HYALOSPHENIA, *Stein.*

8. HYALOSPHENIA PLATYSTOMA, sp. n.   (Pl. 13. figs. 3–6.)

Rather small; shell ovoid in front view, with a semicircular apex
and a widely truncate base, consisting of a colourless, transparent,
chitinoid membrane; sides of shell slightly convex and mouth
very wide; in side view, shell narrowly ovoid, with no trace of a
constriction towards the apex, slightly notched at the mouth.
Protoplasmic body held in position by several fine strands
passing to the inner surface of the shell, inferior part clear,
superior part granular and filled with food-particles; pseudo-
podia two, short and lobose; nucleus dorsal and prominent;
contractile vacuoles not observed.

Length of shell 40–42 μ; breadth of shell 28–32 μ; breadth
of mouth 21–26 μ; thickness of shell 14–15 μ.

Hab. Near Tarbert, Harris, Outer Hebrides.

Numerous active specimens of the above species were observed
in a collection from a *Sphagnum*-bog. The small size of the
shell and the extremely broad mouth are features which easily
distinguish it. In the side view, there is no trace of a con-
striction towards the apex of the shell, and there is a distinct
line of demarcation between the lower part of the body-pro-
toplasm, which gives origin to the pseudopodia, and the upper
granular portion.

The species stands nearest to *H. minuta,* Cash (Trans. Manchester Micr. Soc. 1891, p. 49, pl. 11. figs. 3–4), but the form of the shell is different, the mouth being much broader and more truncate, and the body-protoplasm and pseudopodia exhibit rather different characters.

9. HYALOSPHENIA INCONSPICUA, sp. n.   (Pl. **13**. figs. 7–11.)
Very minute; shell thin, of a reddish-brown colour, in front view with an almost circular outline, the basal portion being slightly protracted to form a short neck ; mouth small and truncate; in side view, shell ovate-elliptical in form, with a notched mouth.   Protoplasmic body occupying only about half the cavity of the shell and furnished with a small nucleus; with one short pseudopodium; contractile vacuoles not observed.

Length of shell 14·5–17 μ; breadth of shell 12·5–16 μ; breadth of mouth 6·5–7·7 μ; thickness of shell 8·6 μ.

Hab. Lough Gartan, Co. Donegal, Ireland.

This minute *Hyalosphenia,* which is considerably smaller than any other known species, was observed in quantity from the above locality in May 1901.   The almost circular outline of the shell and the reddish-brown colour are characteristic.   The animals were very sluggish, and only protruded one small pseudopodium.

Family EUGLYPHINA.

Genus EUGLYPHA, *Dujardin.*

10. EUGLYPHA CRISTATA, *Leidy, in Proc. Acad. Nat. Sci. Philad.* 1874, p. 226; *Freshw. Rhiz. N. Amer.* 1879, p. 218, pl. 37. figs. 1–4.

Length of shell (without bristles) 65–104 μ; breadth 27–31 μ.

Hab. Rhiconich, Sutherland ; frequent.   Also near Tarbert, Harris, Outer Hebrides.

Some of the examples were very rounded at the apex, but others were more attenuated towards the apex, and also furnished with a slight neck at the base.

Genus SPHENODERIA, *Schlumberger.*

11. SPHENODERIA PULCHELLA, sp. n.   (Pl. **13**. figs. 12–15.)
Shell ovoid or ellipsoid, in vertical view circular, composed of

six longitudinal rows of widely hexagonal plates, 8 or 9 plates in each row, with a short cylindrical neck at one pole; mouth circular, often with an irregular border; plates transparent, chitinoid, colourless or pale yellow; body-protoplasm protruding some three or four delicate thread-like pseudopodia.

Length of shell 33–42 μ; diameter of shell 21–25 μ; diameter of mouth 5–7·8 μ.

Hab. Glenties and near Lough Machugh, Co. Donegal; and east of Recess, Co. Galway, Ireland.

Living specimens of this pretty little Rhizopod were only observed from Glenties, Co. Donegal. From the other localities only empty shells were seen, but these are unmistakable.

It is nearest to *S. macrolepis*, Leidy, but is easily distinguished by its larger size, smaller mouth, and by the six equal rows of plates. In most cases the short neck was cylindrical, but a few specimens were seen in which it was slightly compressed. The form of the shell and the arrangement of the plates at once distinguish it from *S. lenta*, Schlumbg.

Family GROMIINA.

Genus PAMPHAGUS, *Bailey.*

12. PAMPHAGUS HYALINUS, *Leidy, Freshw. Rhiz. N. Amer.* 1879, p. 194, pl. 33. figs. 13–17.—Arcella? hyalina, *Ehrenb.*, 1838. —Gromia hyalina, *Schlumberger*, 1845.—Lecythium hyalinum, *Hertwig & Lesser*, 1874.

Hab. Sligachan, Skye; abundant in pools.

The animals were all somewhat elongate, about 40–50 μ in length and 26–29 μ in breadth, and the pseudopodia were extended more than is usual for this species, reaching a length of 73 μ.

Family AMPHISTOMINA.

Genus DIPLOPHRYS, *Barker.*

13. DIPLOPHRYS ARCHERII, *Barker, in Qu. Journ. Micr. Sci.* 1868, p. 123; *Hertwig & Lesser, in Archiv für mikr. Anat.* x. (1874), Suppl. p. 139, pl. 3. fig. 9.

Hab. Loch Gatny, Co. Donegal.

West

Linn. Soc. Journ. Zool. Vol. XXIX. Pl. 13.

BRITISH RHIZOPODS.
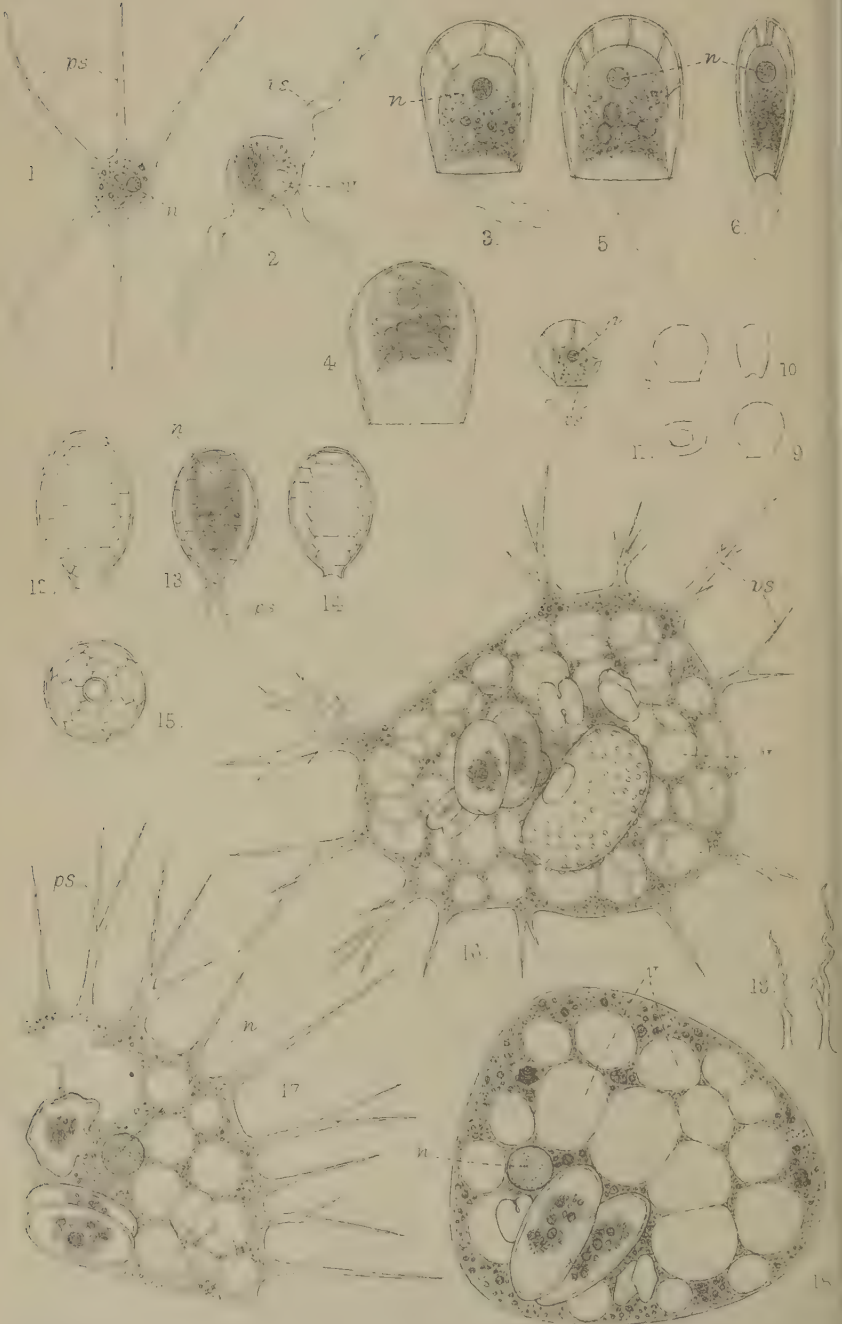
EXPLANATION OF PLATE 13.

cv = contractile vacuole. n = nucleus. ps = pseudopodia. v = vacuole.
All the figures × 520.

Figs. 1–2. *Dactylosphærium radiosum*, Blochmann.   Two forms; fig. 2, showing spirally-twisted pseudopodia.

3–6. *Hyalosphenia platystoma*, sp. n.   Figs. 3–5 showing the front view of the shell with its broad aperture; fig. 6, seen from the side. Fig. 4 shows a curiously contracted state of the animal in which the body-protoplasm is closely applied to the dorsal part of the shell.

7–11. *Hyalosphenia inconspicua*, sp. n.   Fig. 7, living animal, showing pseudopodium and nucleus; figs. 8–11, empty shells.   Fig. 11 is the basal view of a shell showing the elliptical mouth.

12–15. *Sphenoderia pulchella*, sp. n.   Figs. 12, 14, and 15, empty shells; fig. 13, living animal.   Fig. 15 is the basal view of the shell, showing the small, round aperture.

16–19. *Nuclearia conspicua*, sp. n.   Figs. 16 and 17, animals with pseudopodia extended; fig. 18, contracted state of the animal.   These animals contain a number of Desmids, the bodies of which have been more or less digested.   Fig. 19, two pseudopodia after slight mechanical stimulation.

The *Ingolfiellidæ*, fam. n., a new Type of Amphipoda.
By Dr. H. J. HANSEN (Copenhagen), F.M.L.S.

[Read 7th May, 1903.]

(PLATES **14** & **15**.)

THE greatest depth explored by the Danish 'Ingolf' Expedition (during the two summers of 1895 and 1896) was 1870 fathoms, and the Station in question (No. 38) is a little south of the entrance to Davis Strait.   In the trawl was obtained slightly more than one litre of mud, which was carefully treated with a sieve covered with silk-gauze.   This small portion of bottom-material contained a number of Crustacea new to science, among which were two new aberrant types of very small sessile-eyed Malacostraca.   Of one of these forms only a single specimen could be detected; it presents a rather strong resemblance to the Caprellidæ, but it is at once apparent that the pleopods on the long abdomen differ exceedingly from those of every other Amphipod hitherto known.   Some years after I found a specimen of an allied species in sieved material procured by

Dr. Th. Mortensen on the shore of one of the islands in the Gulf of Siam. In the report on the Crustacea collected by the 'Ingolf' to be published in the future, I could scarcely include the Siamese species, and I resolved therefore to give a separate account of both forms. The type deviates so much from other Amphipoda in several particulars, that the publication of this treatise on the family may be justified.

It may be convenient to begin with the description of the two species; secondly, to point out the essential characters of the type, comparing it with other Amphipoda; then to supply a diagnosis of the new family; finally to set forth some remarks on the tribes of the Amphipoda and the place and rank of the *Ingolfiellidæ*, fam. nova.

I. *Description of the Species.*

1. INGOLFIELLA ABYSSI, n. gen. et n. sp.   (Pl. 14. figs. 1–18 ; Pl. 15. figs. 19–21.)

Body (fig. 1).—The animal is very elongate, between fourteen and fifteen times longer than deep, round, thus being filiform, and without processes or tubercles; hairs are not to be found on the head, the thorax or the abdomen, the telson excepted. The first thoracic segment is considerably deeper in front than posteriorly, more closely connected with the head than with the second thoracic segment, yet sharply separated from the head, but the movement which may be possible between these two parts must at most be rather feeble. The second thoracic segment is much longer but not deeper than the first, one and a half times longer than deep; from this segment to the third segment of the abdomen the segments increase gradually somewhat in depth, and the last-named segment is as long as the sum of the second thoracic segment and one half of the first segment, but not quite twice as deep as the second. The third abdominal segment has the lower portion of the postero-lateral margin very oblique, without vestige of any angle, and the following segments decrease posteriorly in depth and length. The abdomen is slightly shorter than the combined length of the six posterior thoracic segments; its segments are all excellently defined. The thoracic 'epimera' are not developed as plates, but only as small basal joints of the legs.

Head (fig. 2).—It is more than one and a half times longer than deep; rounded. A small angle is developed dorsally between

the insertions of the antennulæ, but a real 'rostrum' does not exist. The angle between the antero-lateral and the lower lateral margin is rounded off, and this lower margin is without any protruding angle or process. The antero-lateral margin has at the middle a small plate *which is marked off by a real articulation*; this plate, which is freely projecting, and somewhat higher than long, with the anterior margin curved, must be interpreted as an eye-lobe, but visual elements could not be discovered.

Antennulæ (fig. 2).—These are slightly longer than the head and the two anterior thoracic segments. The peduncle measures a little more than two-thirds of the whole antennula; its basal joint is rather robust and somewhat longer than the sum of the two distal joints, which are subequal in length and considerably more slender than the first; each of the two distal joints with two subapical short hairs. The flagellum consists of four joints, decreasing much in thickness from the second to the fourth (fig. 3); the first joint is about as long as deep, the second considerably longer, as long as the third, which is slightly shorter than the fourth; the second and third joints each with two or three subapical setæ; the fourth joint with about seven apical setæ of various length. On the distal lower angle of the three distal joints is found an olfactory seta (*o.*); the proximal seta is as long as the terminal joint, and the two others a little shorter; all these setæ are thick, with the end broadly obtuse and the wall membranous. An accessory flagellum (fig. 3, *a.*) is developed, originating from the inner and lower side of the end of the peduncle, and reaching a little beyond the middle of the second joint of the other flagellum; it is three-jointed, the first and the third joint short and subequal in length, the second somewhat longer than both combined; the two distal joints each with a couple of short hairs.

Antennæ (fig. 2).—These are a little shorter than the antennulæ, and as a whole somewhat more slender. The peduncle is slightly more than twice as long as the flagellum; its three distal joints decrease from the base in length and thickness; the proximal short joints without any projecting angle or spine; the penultimate joint with a single seta on the lower side. The flagellum is slender, decreases gradually in thickness, and consists of five joints; the four proximal joints are subequal in length, the fifth slightly longer; each of the two distal joints has a few short apical setæ.

Mouth.—The *labrum* (fig. 4) is considerably broader than long, rounded on the sides; the posterior margin with the middle half rather strongly convex.—The *left mandible* is shown from below and a little from the outer side in fig. 5, while fig. 6 exhibits its distal half from behind and below with a higher degree of enlargement. The cutting-edge is rather short, with a submedian incision. The movable lobe, 'lacinia mobilis' (*l.*), consists of a large plate and four setæ; the plate has both the anterior and the posterior angle of the terminal edge produced into a small tooth, while the setæ are very thick and increase much in thickness towards the end, which has an incision on the terminal margin. The molar process (*m.*) is very curious, *being shaped as a very long, very slender, and nearly straight cone,* the distal part of which is exceedingly slender with the apex acute. A mandibular palp is wanting. The right mandible has been seen only from below; some smaller differences exist most probably between it and the left mandible in the shape of the cutting-edge, and especially of the movable lobe, but the molar process is formed as that of the other mandible.—The *hypopharynx* (paragnatha) (fig. 9) has a very oblique, rather thick lobe on each side; the lobe terminates anteriorly near the median line in an obtuse end adorned with a couple of very short setæ.—The *maxillulæ* (fig. 7) are interesting, but 1 have not been able to make out the elements of their basal portion. The inner lobe (originating from the first joint) is rather well developed, with two short setæ on its terminal margin; the outer lobe (originating from the third joint) is strong, distally truncate, with about five very thick setæ, and three of these are adorned with branches on their inner side. The palp is well developed, and consists, as in most Gammarina, of two joints, but the first is longer than in any other Amphipod known to me, much longer and somewhat broader than the second joint, which has four elongate setæ on the terminal margin.—The *maxillæ* (fig. 8) are much smaller than the maxillulæ; the basal elements could not be distinguished from each other; the two lobes are rather short and broad, with some long and moderately strong setæ on the terminal margin.— The *maxillipeds* (fig. 10) are long, seven-jointed; the first joint of one maxilliped is coalesced in slightly more than two-thirds of its length with the corresponding joint of the other appendage; the second joint is on the inner half of the upper side produced into a lobe which is not marked off by any suture, reaches almost

to the end of the third joint, and has a couple of short setæ on the terminal rounded margin. The third joint is slightly longer than the second, *without a vestige of any lobe*, but with two setæ on the lower side near the inner margin. The three following joints are somewhat longer than the proximal ones, each with only one seta, which on the fourth and fifth joints is inserted at the inner margin, on the sixth more distant from that margin. The seventh joint is subconical, with two distal setæ, and terminating in a long setiform claw.

First Pair of Thoracic Legs (fig. 2).—The basal joint is short, considerably broader than long, rounded off anteriorly. The second joint is nearly as long as the segment, about twice as long as broad, with the posterior margin very convex. The third and fourth joints are short, with a short subapical hair on the lower margin. *The fifth joint forms the hand*, which is somewhat longer than the head, oblong, almost three times longer than broad, with the anterior margin rather strongly but not regularly convex; the apparent posterior margin is as a whole sinuate but slightly convex, consisting of the palm and the free posterior margin, which are marked off from each other by a minute process (fig. 11, *p.*), and the palm is two and a half times longer than the free posterior margin. The palm (fig. 11) presents a feeble, somewhat angular incision near its proximal end, and just above that point a rather small but robust spine originating on the inner surface near the margin; the palm beyond the incision is feebly convex, with some faint saw-teeth and a few minute hairs on the distal half, on the proximal half a small spine from the inner surface and two short setæ on the outer side. In the hand no internal gland could be discovered. The finger consists of three elements about equal in length, viz., the sixth joint, the seventh joint, and the real claw (fig. 11); notwithstanding *the whole finger is claw-shaped*, considerably curved, and about two-thirds as long as the hand. The articulation between the sixth and the seventh joint is irregularly sinuate and the movement allowed must be slight; the sixth joint contains, however, two slender muscles to the seventh joint. The seventh joint is coalesced with the claw, a transverse suture between them cannot be discovered, but the posterior distal angle of the joint is produced into an oblong triangle, which is sharply marked off from the posterior margin of the claw.

Second Pair of Thoracic Legs (fig. 2).—In the main similar to

those of the first pair, but differing in a number of rather small features. The basal joint is much broader but not longer than that of the first leg, not produced. The second joint as long as that of the preceding pair, but it increases almost gradually in breadth from the base to the end, and the posterior margin is slightly convex. The fifth joint, the hand, is somewhat shorter but not more slender than that of the first pair, two and a half times longer than broad, with the anterior margin considerably less convex than that of the first pair, and the basal third is much broader than the distal third. The apparent posterior (lower) margin of the hand is constituted of the real posterior margin and the palm; these two parts are marked off from each other by a small triangular process (fig. 12, *p.*), and the palm is two and a half times longer than the margin mentioned. The palm presents the same two proximal spines as that of the first pair, but these spines are somewhat longer and considerably thicker; the major portion of the palm shows a number of minute saw-teeth and differs as a whole slightly from that of the first leg. The sixth and seventh joints (fig. 12) are a little thicker than the corresponding joints of the first leg; otherwise these joints and the claw do not present any deviating feature.

Third and fourth Pairs of Thoracic Legs (fig. 13).—These are equal in size and shape, each about as long as the sum of the third and fourth thoracic segments (fig. 1), and very slender. The first joint is small, transverse, about as broad as the second joint, which is two and a half times longer than broad. The fourth joint is somewhat shorter than, but as broad as the fifth, which is scarcely as long as but somewhat broader than the sixth. The seventh joint is oblong, not half as long as the sixth; the claw (fig. 14, *c.*) is well marked off, somewhat longer than the seventh joint (VII.), slightly curved, slender, decreasing a little in breadth from the base to a small spiniform tooth originating at the beginning of the very short, thin, and acute terminal portion. A single subapical seta on the fourth and the fifth joints, a couple of apical thin setæ on the sixth, and a very short apical seta on the seventh joint.—No glands could be discovered in these legs.

Fifth and sixth Pairs of Thoracic Legs (fig. 15).—Rather similar to the fourth pair, but a little shorter and differing in several smaller points. The second joint is somewhat broader; the fifth joint is slightly longer than the fourth, with about four

thick setæ along the terminal margin ; the sixth joint is some-
what shorter and considerably more slender than the fifth ; the
claw (fig. 16, c.) is shaped as a moderately slender seta.

Seventh Pair of Thoracic Legs (fig. 17).—These are slightly
longer than those of the fourth pair, with almost all the joints
considerably more slender, and deviate besides in the following
particulars :—The fourth joint is somewhat longer than the fifth,
with a long apical seta on the posterior margin ; the fifth joint
posteriorly on the end with a couple of short setæ ; the sixth
joint is longer than the fifth ; the claw is setiform.

Pleopods (fig. 18, *pl.*).—These are all equal as to shape and
size. *Each pleopod consists of a moderately small, almost triangular
plate* ; the three margins of the triangle do not differ much from
each other in length and all are a little convex ; setæ are com-
pletely wanting, but at the postero-superior angle two feeble
serrations can be seen ; it is very movable, attached by the
anterior end which is a little truncate. This plate is homologous
with the long distal joint of the sympod ; the basal portion of
the sympod is absent in this species (in the following form it
consists of a distinct joint).

Uropods (fig. 18).—The two anterior pairs are well developed,
each of them consisting of a peduncle and two rami. The
peduncle of the first pair is a little more than half as long as the
segment, rather compressed, with the basal half of the outer side
widened as a rounded wing ; the outer ramus is styliform, slender,
acute, and slightly shorter than the inner one ; the latter is
shaped as a very oblong plate, slightly shorter than the peduncle,
with about two longitudinal rows of long setæ on the inner side
(fig. 19) near the upper margin, and terminating in four spiniform
processes arranged in a very oblique row. The peduncle of the
second pair is as long as its segment, somewhat longer and much
broader than that of the first pair, moderately compressed on
the distal half of its inner side, with four very oblique comb-
shaped rows of numerous slender spines (fig. 20), and a single
longer seta at the upper end of each of these rows ; the rami are
curved, acute styles, the outer one somewhat shorter than the
other, and both with a few setæ on the proximal part. The third
pair of uropods are very small, almost rudimentary (fig. 18) ;
each (fig. 21) consists of two joints : the basal joint is short and
very thick, the other is many times smaller, rounded, terminating
in a single long seta.

Telson (fig. 18).—The telson is short, deep, rounded, with a couple of dorsal setæ.

Branchiæ.—An oblong branchia is found at the base of the third, fourth, and fifth pairs of legs; those belonging to the third and fourth pairs (fig. 13, *b.*) are longer and more narrow than the branchiæ of the fifth pair (fig. 15).

Age and Sex.—Marsupial lamellæ are entirely wanting; neither have I been able to discover male copulatory organs, but it must be added that in order to spare the legs of the animal I did not venture to examine it vertically from below. The specimens must therefore be regarded as probably immature, and I cannot determine the sex.

Length.—The specimen measures 2·5 mm. in length.

Locality.—The 'Ingolf' Expedition, Station 38; lat. N. 59° 12', long. W. 51° 05'; 1870 fathoms; temperature at the bottom 1°·3; July 30, 1895.

Remarks.—The essential differences between this and the following species will be pointed out in 'Remarks' on the latter form.

2. INGOLFIELLA LITTORALIS, n. sp.   (Pl. 15. figs. 22–33.)

Body.—The animal is a little thicker in proportion to the length than the preceding species, almost thirteen times longer than deep; the third abdominal segment is only a little longer than deep. In other respects it is similar to *I. abyssi*, with the exception that the head, all thoracic and the five anterior abdominal segments are adorned with rather short dorsal setæ, one pair on each segment; on the head and the first thoracic segment these setæ are situated near the anterior margin (fig. 22), on the other segments at the end of the anterior fourth or third part (figs. 22 & 32).

Head (fig. 22).—The head differs from that of the preceding species in two particulars. The lower lateral margin has somewhat behind the base of the antennæ a prominent pointed angle. The eye-lobe is triangular, about as long as high, with the front end acute and the upper portion of its base not touching the lateral margin of the head; no visual organs could be detected.

Antennula (fig. 22).—These are slightly shorter than the sum of the head and the two anterior thoracic segments, somewhat more robust than in the preceding species and deviating besides in some particulars. The peduncle measures somewhat more than three-fourths of the whole appendage, and its basal joint,

which is somewhat thickened in the proximal half, measures almost one half of the whole antennula, while the two distal joints are subequal in length; all three joints with a few subapical setæ. The flagellum consists, as in *I. abyssi*, of four joints (fig. 23), but the second joint is as long as the first, and all joints, especially the third, are considerably thicker; the normal setæ as in the preceding form. Three olfactory setæ are also found in *I. littoralis*, but those on the second and the fourth joint are considerably shorter than that on the third joint, and the last-named seta is a good deal longer than its joint. The accessory flagellum (fig. 23) nearly as in *I. abyssi*, but a little thicker and reaching almost to the end of the second joint of the other flagellum.

Antennæ (fig. 22).—These are somewhat shorter than the antennulæ, considerably thicker than in *I. abyssi*, and differing in some other particulars. The peduncle is four times as long as the flagellum; of its three distal joints the intermediate one is considerably longer and a little thicker than the preceding joint, which is a little longer and considerably thicker than the terminal one. The flagellum consists, as in *I. abyssi*, of five joints, and it decreases gradually in thickness from the base to the end; the four proximal joints are subequal in length, while the fifth is very small. The antennæ possess more setæ than in *I. abyssi*, but their arrangement and length are shown in the figure.

Mouth.—I have not separated the appendages by dissection, but a view from the side did not present any difference worth mentioning from the preceding species.

First Pair of Thoracic Legs (fig. 22).—In the main similar to the same pair of *I. abyssi*, but presenting yet some specific characters. The first joint is considerably larger than in the other species, anteriorly produced in a triangular plate terminating in a seta. The hand is considerably longer than the head, two and a half times longer than deep; the anterior margin is rather strongly convex; the apparent posterior margin as a whole moderately convex; the palm is only a little longer than the real posterior margin and marked off from it by a small spiniform process. The proximal part of the palm has a rather long and thick marginal spine, and on each side of this a small spine (fig. 24) originating from the inner side near the margin. The sixth and seventh joints with the claw as in *I. abyssi*.

Second Pair of Thoracic Legs (fig. 25).—A little smaller than the first pair. The first joint is slightly produced anteriorly; the four proximal joints almost similar to those in *I. abyssi* but a little more slender, while the hand and the seventh joint present excellent specific characters. The hand is slightly more than twice as long as broad, increasing gradually in breadth from the base to the heel, which is situated at the end of the second third of the whole length. The free posterior margin is almost as long as the palm, which presents (fig. 26) some rather large irregular teeth, at the heel a rather long and thick spine, and just in front of this spine a smaller spine originating from the inner side near the margin. The sixth joint is twice as long as broad. The seventh joint (fig. 26) has on the posterior margin three robust oblique processes, the distal one the longest; the claw is slender, not marked off from the preceding joint.

Third and fourth Pairs of Thoracic Legs.—These are rather similar to the corresponding pairs of *I. abyssi,* but differ in some particulars. Almost all the joints are thicker (fig. 27) and their setæ a little more numerous; the fourth joint is only a little shorter than the fifth and as long as the sixth; the seventh joint has the postero-inferior angle somewhat produced, but rounded and terminating in a very short hair (fig. 28, VII.); the claw is shorter and thicker than in *I. abyssi*, terminating in two small diverging spiniform processes.

Fifth, sixth, and seventh Pairs of Thoracic Legs.—These legs are similar in structure, but the two anterior pairs (fig. 29) are somewhat shorter and considerably more robust than the seventh pair (fig. 31). They differ greatly from the corresponding pairs in *I. abyssi* in having the sixth joint a little longer than and as thick as the fourth, and especially in the structure of the terminal portion of the legs; the seventh joint is fused with the claw, and both these elements form together a robust curved " claw " (fig. 30), in which sometimes a very faint transverse line indicates its constituting parts, and sometimes this line could not be discerned. Figs. 29 and 31, as compared with figs. 15 and 17, show several smaller differences between these legs and the corresponding pairs of *I. abyssi*.

Pleopods.—The plates (fig. 32, *pl.*, and fig. 33) differ somewhat in shape from those of *I. abyssi*; the upper (outer) margin is only two-thirds as long as the lower one, the lower and the posterior margin form with each other an acute angle, and

the angle between the posterior and the upper margin is produced into a small triangular process directed backwards. The anterior, moderately narrow end of the plate is inserted on a short and rather narrow joint, which is withdrawn beneath the side-plate of the segment.

Uropods.—The first pair (fig. 32) differ from those of *I. abyssi* in two characters: the peduncle is considerably less widened on the outer side of its basal half, and the outer ramus is distinctly broader at the base, but considerably shorter, only half as long as the inner ramus. The second pair (fig. 32) are rather similar to those of *I. abyssi*, but the peduncle is even a little broader, with only three oblique rows of spines on the inner side, and the outer ramus is a little longer than the inner. The third pair are more slender than in *I. abyssi*, and a separate second joint could not be made out, but its long terminal seta is present.

Telson.—Scarcely so deep as in *I. abyssi* and the dorsal setæ are longer (fig. 22), otherwise as in the former species.

Branchiæ.—These are present on the three same pairs of legs as in *I. abyssi*, but they are nearly circular in outline (fig. 27, *b.*; fig. 29).

Age and Sex.—The animal appears to be immature, and the sex could not be made out.

Length.—The specimen measures 1·5 mm. in length.

Locality.—Gulf of Siam, on the coast of the isl. of Koh Chang, in bottom-material obtained (Jan. 17, 1900) by Dr. Th. Mortensen from corals, 1 fathom.

Remarks.—Among the numerous differences between this species and *I. abyssi*, the shape of the " claw " on the three posterior pairs of thoracic legs is, undoubtedly, the most interesting. Among the others some may be especially pointed out, viz., the shape of the eye-lobes, of the basal joint of the first pair of thoracic legs, shape and armature of the first and especially of the second hand with its finger, finally the shape of the pleopods.

II. *The Essential Characters of the Type.*

At the first glance the two species appear somewhat similar to the Caprellidæ, but on a closer examination it is seen that *Ingolfiella* is very distinct from that family, so different, in fact, that it is not more related to it than to some other families : it occupies in reality a very isolated position.

Ingolfiella *is clearly distinguished from all* Amphipoda Gammarina *and* Caprellina (*sens. Stebbing*) *by at least four characters. Two of these are of very high rank, viz. the complete separation of eye-lobes from the head and the structure of the pleopods ; the two other characters are less important, viz. the elongate styliform shape of the molar process of the mandibles, and the structure of the first two pairs of prehensile hands, in which the fifth joint is developed as a hand and the two distal joints, together with the real claw, are so completely claw-shaped that a similar structure has not been observed in any other form.*—Two other characters seldom met with in any other Amphipod, viz., the relative development of the joints of the palp of the maxillulæ, and the structure of the seventh joint with its claw of the third and fourth pairs of thoracic legs, have not been deemed worthy of enumeration together with the four characters above mentioned.

Ingolfiella agrees with the family Caprellidæ—of the tribe Caprellina—in some features : the body is filiform, without " epimeral " plates ; the first thoracic segment is more broadly and more closely connected with the head than with the following segment. But from the tribe Caprellina, *Ingolfiella* is separated not only by the four characters distinguishing it from all Amphipoda, but also by some other features to be enumerated. The antennulæ have an accessory flagellum which is absent in the Caprellina ; the abdomen, which is only a little shorter than the thorax, has the full number of well-defined segments and six pairs of appendages ; the seventh joint and the claw are very sharply separated on the third and fourth pairs of thoracic legs ; branchiæ are present on the third, fourth, and fifth pairs of legs, but in the Caprellina branchiæ are always wanting on the fifth pair. Furthermore, *Ingolfiella* differs from the family Caprellidæ in some additional features : in the palp of the maxillulæ the first joint is unusually long, longer than the second, while in the Caprellidæ the second joint is very much longer than the first ; the maxillipeds have no lobe from the third joint and their second joints are not coalesced in the median line, but in the Caprellidæ at least the basal parts of the second joints are coalesced and the third joint has a well-developed lobe ; the first prehensile hand is a little larger than the second, and of both pairs the hand itself is the fifth joint, but in the Caprellidæ the first hand is much smaller than the second and

the hand itself is the sixth joint. All the differences enumerated between *Ingolfiella* on the one side and the tribe Caprellina or especially the family Caprellidæ on the other side, prove that the new type is very distant from the " Læmodipoda " and cannot be regarded as an intermediate form between some family of the Gammarina and the family Caprellidæ.

When *Ingolfiella* is compared with the families of the tribe Gammarina, fresh difficulties are met with. The genus differs from all Gammarina hitherto known not only by the four characters printed above in italics, but besides by the filiform body without " epimeral " thoracic plates and by some other less important characters. It is easy enough to see that it has nothing to do with such families as the Lysianassidæ, the Ampeliscidæ, the Stegocephalidæ, the Gammaridæ, &c., but it is impossible for me to point out any family to which it is really related. When we compare it with the Corophiidæ and the Dulichiidæ (sens. Sars), the two families in which the epimeral plates are at most of very moderate size and sometimes small, and the last pair of uropods reduced or wanting, several differences are easily observed. The mandibles of *Ingolfiella* differ not only in the above-mentioned styliform molar process—in the two last-named families this process is short, thick, broadly truncate, and adapted for mastication—but also in its general shape and by not possessing the palp. In the maxillulæ of *Ingolfiella* the palp has the first joint proportionately elongate, the second joint short, while the first joint is short, the second very long in the Corophiidæ and Dulichiidæ as in all other Gammarina possessing a palp of normal length. I am acquainted with only one instance which may be said to be intermediate between *Ingolfiella* and other Gammarids, viz., the palp of *Eusiropsis Riisei*, Stebbing, which, according to that author (Trans. Linn. Soc. ser. 2, Zool. vol. vii. part 2, p. 40), " has a stout first joint, but the second is weak and tapering, scarcely longer than the first . . ." In the maxillipeds the third joint is without any lobe, but in the two families named this lobe is very large, much larger than the lobe from the second joint. The disappearance of the lobe from the third joint is very rare in the tribe Gammarina: Sars says (Crust. of Norway, vol. i. p. 234) that these lobes are " obsolete " in the family Stenothoidæ ; in his figures of those appendages of *Stenothoë* and *Probolium* a rudiment of the lobes can be seen, but in *Metopa Alderi* (Bate)

they are absent (pl. 86); furthermore, the lobe has com-
pletely disappeared in *Anamixis Hanseni*, Stebbing (op. cit.
p. 36, pl. 11). That the eyes have altogether disappeared
in *I. abyssi* is not surprising, but it is very curious that they
are also entirely wanting in *I. littoralis*, procured at a depth
of only 1 fathom on the coast of an island surrounded by
shallow water. So far as I know, no blind Amphipod living on
the shore has been described. The antennulæ and antennæ of
Ingolfiella are rather short and with very few hairs; they differ
much from the same appendages in Corophiidæ and Dulichiidæ.
The five posterior pairs of thoracic legs differ in general aspect
by being slender and short, but the third and fourth pairs differ
more materially in that the seventh joint and the claw do not
resemble a "claw" as in the Corophiidæ, Dulichiidæ, and
probably all other Gammarina.

III. *Diagnosis of the Family.*

That *Ingolfiella* must form the type of a new family, the
Ingolfiellidæ, is, in my opinion, proved by the statements in
the preceding section. The diagnosis of the family may be as
follows :—

Body filiform, with the basal joint of the thoracic legs small,
not developed as "epimeral" plates. Separate eye-lobes
(without eyes) developed from the antero-lateral margin of the
head. The antennulæ with accessory flagellum. The mandible
with elongate styliform acute molar process. The first joint
of the well-developed palp of the maxillulæ longer than the
second. The maxillipeds only with the major part of their first
joints coalesced with each other; the third joint without lobe.
The first segment of the thorax more closely connected with the
head than with the second segment. The two anterior pairs
of thoracic legs with a well-developed hand formed of the fifth
segment, while the rest of these legs is claw-shaped; the pre-
hensile hand of the first pair larger than the following pair.
The third and fourth pairs of thoracic legs with a thin claw
inserted on a much broader seventh joint. The abdomen long,
with all the segments well separated from each other; the
terminal joint of the sympod of the pleopods developed as a
triangular plate without vestige of rami, hairs, or coupling-hooks.

The two anterior pairs of uropods normal; the third pair reduced. The telson thick, rounded.

When more material of the two species established in this paper has been procured, and new forms have been detected, it is possible that one or a few characters (marsupial plates, &c.) may be added to this diagnosis, and that some of the characters enumerated will be found to be only of generic value. From the structure of the antennulæ and antennæ, of the prehensile hands, the uropods, &c., it would be possible to compose a diagnosis for the genus, but only two species being as yet known a diagnosis would be rather uncertain, and I abstain therefore from the attempt.

IV. *The Rank and Position of the Family* Ingolfiellidæ *in the System.*

The order Amphipoda is generally divided into three tribes or suborders—Hyperina (Hyperidea), Gammarina (Gammaridea), and Caprellina (Caprellidea, Læmodipoda); and this division is maintained by the best modern authorities (Stebbing, G. O. Sars). The Hyperina is, so far as I can see, a very natural group compared with the other two tribes taken together, even if the diagnosis hitherto given for it should prove capable of being a little altered. The separation of the Caprellina from the Gammarina is, in my opinion, not very important from a strictly scientific point of view, but it is certainly very practical, and may therefore be accepted. If this separation is maintained, I think it necessary to establish a fourth tribe for the reception of the Ingolfiellidæ : this family is, according to the characters pointed out above, even more distant from the Corophiidæ, Dulichiidæ, &c., or from the Caprellidæ, than the last-named family, containing such genera as *Cercops* and *Proto*, is remote from the Dulichiidæ. So long as forms intermediate between *Ingolfiella* and some genus of the tribe Gammarina are not discovered, it will be necessary to maintain the Ingolfiellidæ as a tribe of the same rank as the Caprellina, and consider both as *parallel and analogous*; if the last-named tribe is withdrawn the tribe Ingolfiellina must also be suppressed and reduced to only a family of the Gammarina, which then should contain all genera not belonging to the Hyperina.

EXPLANATION OF THE PLATES.

PLATE 14.

Ingolfiella abyssi, n. gen. et n. sp.

Fig. 1. The animal; × 28.
2. Head and the two anterior thoracic segments; × 82.
3. Distal part of the left antennula, from the outer side; × 164.
   a., accessory flagellum; *o.*, olfactory setæ.
4. Labrum, from below; × 300.
5. Left mandible, from below and a little from the outer side; × 300.
6. Distal half of the left mandible, from behind and below; × 380.
   l., movable lobe; *m.*, molar process.
7. Right maxillula, from below; × 300.
8. Right maxilla, from below; × 300.
9. Hypopharynx, from below; × 300.
10. Right maxilliped, from below; × 300.
11. Distal part of the hand and the following joints of the left first
   thoracic leg, from the outer side; × 170. vi., sixth joint, containing
   two small muscles; vii., seventh joint; *c.*, claw; *p.*, process between
   the real posterior margin and the palm.
12. Second left prehensile hand, from the inner side; × 187. *p.*, process
   between the real posterior margin and the palm.
13. Fourth left thoracic leg, from the outer side; × 82. *b.*, branchia.
14. Distal part of the fourth left thoracic leg; × 170. vii., seventh joint;
   c., claw.
15. Fifth left thoracic leg, from the outer side; × 82.
16. Distal part of the fifth left thoracic leg; × 170. vi., sixth joint;
   c., claw.
17. Seventh left thoracic leg, from the outer side; × 82.
18. The five posterior abdominal segments with their appendages; × 82.
   pl., third left pleopod.

PLATE 15.

Figs. 19–21. *Ingolfiella abyssi*, n. sp.

Fig. 19. Distal part of the first right uropod, from the inner side; × 193.
20. Second right uropod, from the inner side; × 193.
21. Third left uropod, from the outer side; × 240.

Figs 22–33. *Ingolfiella littoralis*, n. sp.

Fig. 22. Head and first thoracic segment; × 130.
23. Distal part of the right antennula from the inner side; × 310.
24. Distal part of the hand and following joints of the left first thoracic
   leg, from the inner side; × 310.
25. Second right thoracic leg, from the outer side; × 130.

A NEW TYPE OF AMPHIPODA

A NEW TYPE OF AMPHIPODA
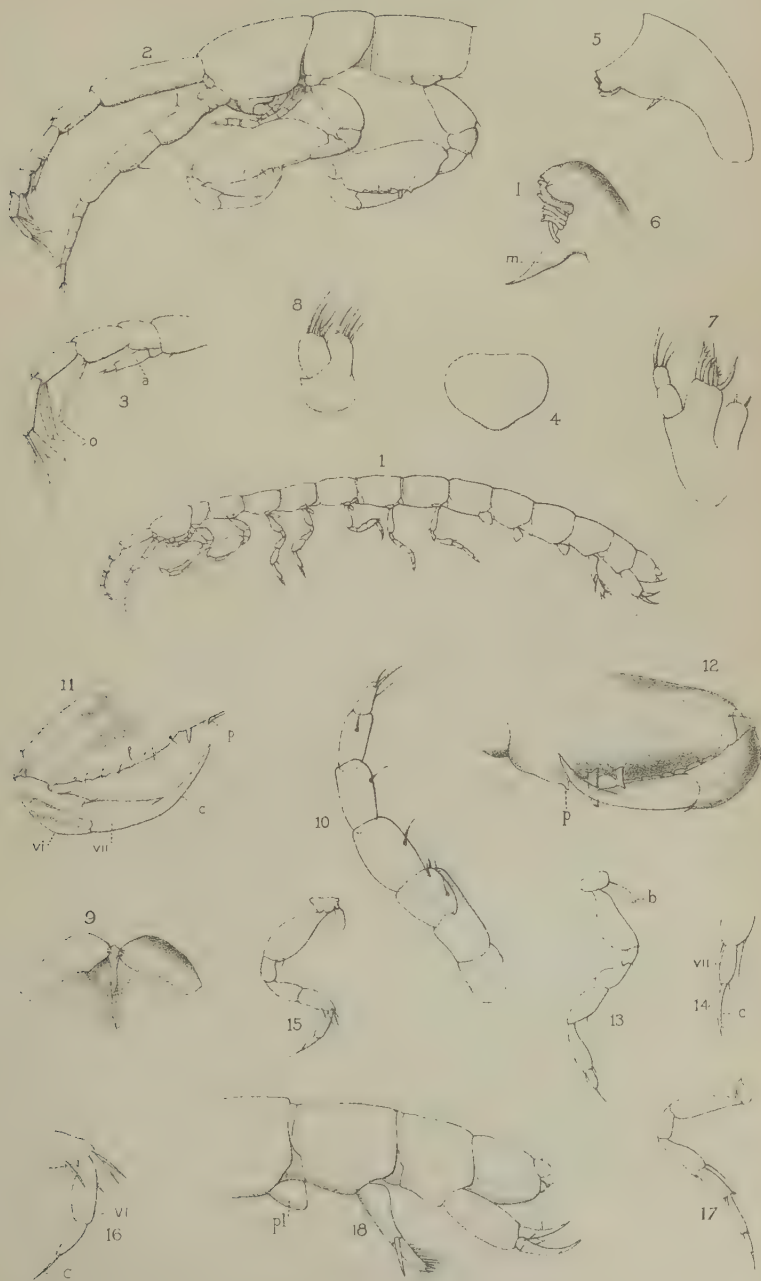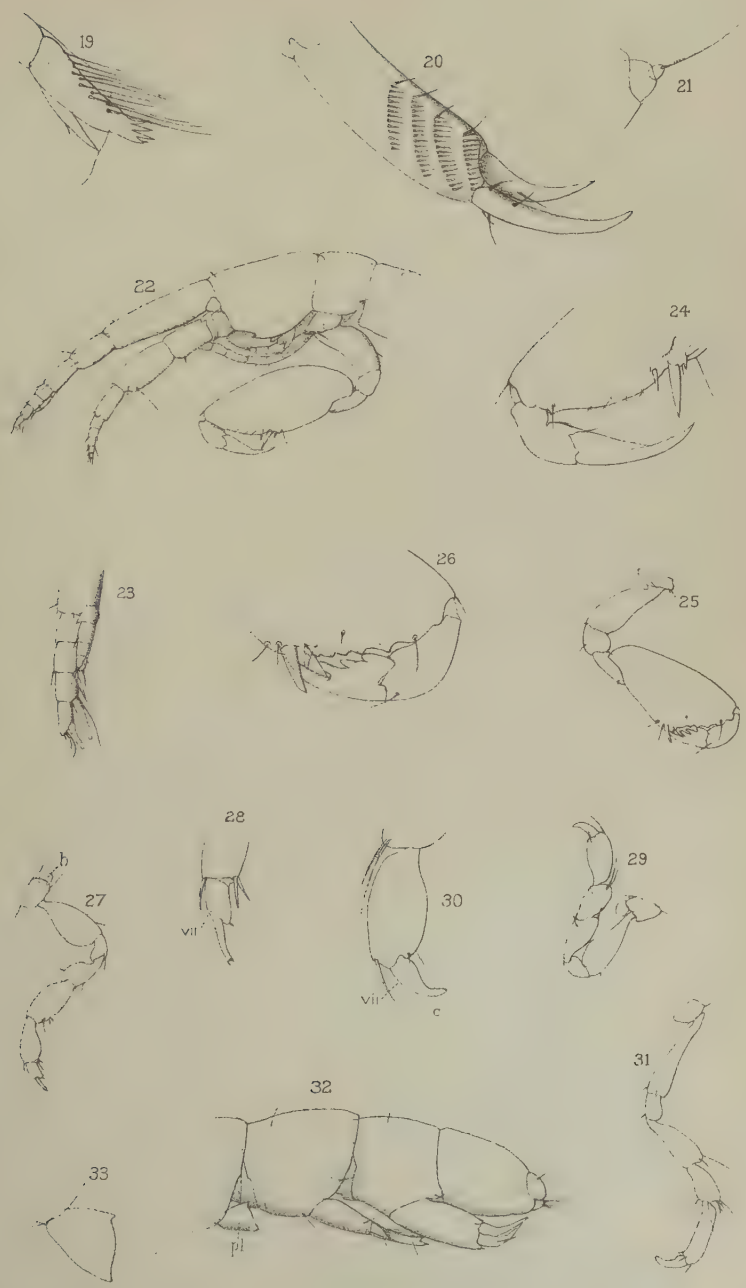
Fig. 26. Distal part of the second right prehensile hand, from the outer side ;
          × 310.
     27. Fourth left thoracic leg, from the outer side ; × 130. *b.*, branchia.
     28. Distal part of the fourth left thoracic leg, from the outer side ; × 310.
          VII., seventh joint.
     29. Fifth right thoracic leg, from the outer side ; × 130.
     30. Distal part of the fifth right thoracic leg, from the outer side ; × 295.
          VII., seventh joint ; *c.*, claw.
     31. Seventh left thoracic leg, from the outer side ; × 130.
     32. The posterior segments of the abdomen with their appendages ; × 130.
          pl., pleopod of the third pair.
     33. First left pleopod, from the outer side ; × 310.

COPEPODA CALANOIDA, chiefly Abyssal, from the Faroe Channel
     and other parts of the North Atlantic. By Canon A. M.
     NORMAN, M.A., D.C.L., LL.D., F.R.S., F.L.S.

[Read 7th May, 1903.]

THE Copepoda to which the following paper has reference are
from the northern parts of the North Atlantic Ocean.   The
larger number of them were procured by Sir John Murray in
the 'Triton' Expedition of 1882, when they were taken in the
Faroe Channel at various depths down to 600 fathoms.   The
deep-water forms were captured in a tow-net attached to, or near
to, the dredge.   It was not a closing net, and therefore the
depths must be regarded only as approximate.   A few specimens
were from the 'Valorous' Expedition of 1875, and the remainder
were the product of a very interesting tow-net gathering sent
to me by Professor Haddon from 200 fathoms, 40 miles N.N.W.
of Achill Head, Ireland.

At the time when they were found, most of the species in this
list were new to science, but pressure of other work prevented
my taking them in hand.   I had named them partially, and
when Professor G. O. Sars commenced his beautiful work, which
is just finished, on the Calanoida, I sent some of these and other
specimens to him for his use, believing at that time that he
purposed to include the species of the Faroe Channel in his work,
but he did not extend its range so far.   He has now returned the
specimens, and I have had the advantage of his determination of
many of the more difficult forms, and of the Arctic species

described by himself from Nansen's voyage, and now found so much further south. Indeed, this paper has far greater interest than if it contained the description of new species.

The enormous range of these deep-water Copepoda is very remarkable. In the Faroe Channel we find species at considerable depths which Nansen met with near the surface at the point nearest to the North Pole from which any animals are known to us; and these are associated with other forms which are known to occur, some in the Mediterranean, some in the Gulf of Guinea and South Atlantic, one in the Antarctic Ocean, and some from the very centre of the Pacific Ocean.

When we consider the matter, we cannot be so greatly surprised at this very wide geographical distribution of abyssal Calanoid Copepoda, since at the depth at which they live—sometimes a varying depth according to latitude—whether under the Tropics or under vast fields of Arctic ice, they are living under conditions where they pass their lives at the same temperature. The isothermal line they are able to find for themselves. Their very active life, almost always on the move, tends of course greatly to wide dispersion, and small as they are, they must of necessity be subject to transportation from one place to another by the action of oceanic currents. We are beginning to learn more and more how widely diffused large numbers of genera and species are which live in the oceanic depths; but in no group of animals has this fact been more clearly demonstrated than in these notes, which record species which, if few in number, are yet, for the most part, of such remarkable distribution.

COPEPODA.

CALANOIDA.

Amphaskandria, *Giesbrecht*.

Fam. CALANIDÆ.

Genus CALANUS, *Leach*.

CALANUS FINMARCHICUS (*Gunnerus*).

Faroe Channel and Davis Strait. This is a surface plankton species abundant in the Arctic seas, and taken by Nansen " up to and beyond 85° of latitude " (*G. O. Sars*).

CALANUS HYPERBOREUS, *Kröyer*=C. magnus, *Lubbock*.

This large Calanoid was taken in the Faroe Channel down to 600 fathoms, and also in Davis Strait.

Fam. EUCALANIDÆ.

Genus RHINCALANUS, *Dana*.

RHINCALANUS NASUTUS, *Giesbrecht*.

1892. *Rhincalanus nasutus*, Giesbrecht, Pelagische Copepoden (Fauna und Flora des Golfes von Neapel, xix.), p. 154, pl. 3. fig. 6, pl. 11. figs. 6, 14, pl. 12. figs. 9-12, 14–16, pl. 35. figs. 46, 47, 49 ; and Das Tierreich, Copepoda, 1898, p. 22.

1901. *Rhincalanus nasutus*, G. O. Sars, Account of the Crustacea of Norway, Copepoda Calanoidea, p. 15, pls. 6 & 7.

Faroe Channel, surface to 40 fathoms ('Triton') ; and 40 miles N.N.W. of Achill Head, Ireland, 220 fathoms (*Haddon*).

Genus EUCALANUS, *Dana*.

EUCALANUS ATTENUATUS (*Dana*).

1853. *Calanus attenuatus*, Dana, U.S. Explor. Exped. vol. xiii. p. 1080, pl. 75. fig. 2.

1856. *Calanus mirabilis*, Lubbock, Tr. Ent. Soc. London, n. s. vol. iv. p. 10, pl. 5.

1863. *Calanella mediterranea*, Claus, Freileb. Copepoden, p. 176, pl. 28. figs. 6–11.

1892. *Calanus attenuatus*, Giesbrecht, *l. c.* p. 131, pl. 3. fig. 1, pl. 11. figs. 1, 11, 13, 16, 18, 24, 40, pl. 35. figs. 3, 6, 17, 25, 34, 37, and 1898, *l. c.* p. 20.

Faroe Channel, 'Triton,' and 40 miles off Achill Head, 200 fathoms (*Haddon*).

Fam. PSEUDOCALANIDÆ, *G. O. Sars*.

Genus PSEUDOCALANUS, *Boeck*.

PSEUDOCALANUS ELONGATUS, *Boeck*.

Faroe Channel.

Fam. ÆTIDIIDÆ, *G. O. Sars.*

Genus ÆTIDIUS, *G. S. Brady.*

ÆTIDIUS ARMATUS (*Boeck*).

1872. *Pseudocalanus armatus*, Boeck, Nye Slægter or Arter af Saltvands-
    copepoder, Christ. Vid.-Selsk. Forhand. p. 38.
1901. *Ætidius armatus*, G. O. Sars, Crustacea Norway, p. 25, pls. 13, 14.

Faroe Channel ('Triton').

Genus GAIDIUS, *Giesbrecht.*

GAIDIUS TENUISPINUS, *G. O. Sars.*

1900. *Chiridius tenuispinus*, G. O. Sars, Norwegian North Polar Exped.,
    Crustacea, p. 67, pl. 18; and 1901, *l. c.* p. 30, pl. 18, ♀; and
    Gaidius tenuispinus, 1903, *l. c.* p. 162, Supplement, pl. 6.
    fig. 1, ♂.

The Faroe Channel, 600 fathoms ('Triton'). The types were
taken by Nansen in the 'Fram' at six stations in the Polar Sea,
the most northern of which was near 85° N.

GAIDIUS BREVISPINUS, *G. O. Sars.*

1900. *Chiridius brevispinus*, G. O. Sars, North Polar Exped. p. 68, pl. 19.
1903. *Gaidius brevispinus* G. O. Sars, Account Crustacea Norway,
    vol. iv. Copepoda Calanoida, Supplement, p. 162, pl. 6. fig. 1.

With the last in 600 fathoms in the Faroe Channel ('Triton').
The type specimens were taken by Nansen in his Polar Expedi-
tion, and were found at the extreme north, 85° 13′ N.; and a
single specimen was taken by the 'Michael Sars' in 1900,
between Jan Mayen and Finmark, "the depth being recorded to
be from 500 and 1000 metres."

Genus GAETANUS, *Giesbrecht.*

GAETANUS MILES, *Giesbrecht.*

1892. *Gaetanus miles*, Giesbrecht, Pelagische Copepoden, p. 219, pl. 14.
    figs. 21, 24, 25, 27, 30, pl. 36. figs. 1, 3; and 1898, p. 32.

Faroe Channel down to 600 fathoms. It has not previously
been recorded north of 35°, but occurs both in the Atlantic and
Pacific Oceans.

GAETANUS ARMIGER, *Giesbrecht.*

1892. *Gaetanus armiger*, Giesbrecht, Pelagische Copepoden, p. 219, pl. 14.
　　　figs. 19, 20, 22, 23, 26, 28, 29, pl. 36. figs. 2, 4, 5; and 1898, *l. c.*
　　　p. 33.
1893. *Ætidius armiger*, T. Scott, Trans. Linn. Soc. ser. 2, vol. vi. (1893)
　　　p. 71, pl. 8. figs. 16–27.

Faroe Channel, in 600 fathoms; not previously known north
of the Gulf of Guinea.

Genus EUCHIRELLA, *Giesbrecht.*

EUCHIRELLA ROSTRATA (*Claus*).

1866. *Undina rostrata*, Claus, Copepoden-Fauna von Nizza, Schrift.
　　　Gesells. gesamm. Naturwiss. Marburg, p. 11, pl. i. fig. 2.
1892. *Euchirella rostrata*, Giesbrecht, *l. c.* p. 232, pl. 2. fig. 11, pl. 15.
　　　figs. 6, 27, 28, pl. 36. figs. 16, 17, 23; and 1898, *l. c.* p. 36.

Faroe Channel, tow-net at 150 fathoms.   Previously only
known in the Mediterranean.

Genus EUCHÆTA, *Philippi.*

EUCHÆTA NORVEGICA, *Boeck.*

1872. *Euchæta norvegica*, Boeck, Nye Slægter or Arter af Saltvands-
　　　copepoder, Christ. Vid.-Selsk. Förh. p. 40.
1902. *Euchæta norvegica*, G. O. Sars, Crustacea Norway, p. 38, pls. 34,
　　　35, 36.

Lat. 50° 1′ N., long. 12° 26′ W., 'Porcupine' 1869: Faroe
Channel down to 500 fathoms, 'Triton' 1882.   Abundant also
in Loch Eteve and Loch Fyne, West Scotland (*Sir J. Murray*).
Nansen took it as far north as 84° 15′.

Fam. SCOLECITRICHIDÆ.

Genus SCOLECITHRIX, *G. S. Brady.*

SCOLECITHRIX SECURIFRONS, *T. Scott.*

1893. *Scolecithrix securifrons*, T. Scott, Trans. Linn. Soc. ser. 2, vol. vi.
　　　(1893) p. 47, pl. 4. figs. 40–56, pl. 5. fig. 1.
1898. *Scolecithrix securifrons*, Giesbrecht, *l. c.* p. 40.

Faroe Channel down to 600 fathoms; and 40 miles N.N.W. of
Achill Head, Ireland, 200 fathoms (*Haddon*).   Previously known
from the Gulf of Guinea and Bay of Biscay.

Heterarthrandria, *Giesbrecht.*

Fam. C E N T R O P A G I D Æ.

Genus CENTROPAGES, *Kröyer.*

CENTROPAGES TYPICUS, *Kröyer.*

Centropages typicus auctorum and *Ichthyophorba denticornis,* Claus.

Faroe Channel ('Triton').

Fam. T E M O R I D Æ.

Genus TEMORA, *Baird.*

TEMORA LONGICORNIS (*Müller*).

Synonyms are *Temora finmarchica,* Baird, *Diaptonus longicaudatus,* Lubbock, and *Halitemora longicornis,* Giesbrecht.

Faroe Channel, surface tow-net.

Genus PHYLLOPUS, *G. S. Brady.*

PHYLLOPUS BIDENTATUS, *G. S. Brady.*

1882. *Phyllopus bidentatus,* G. S. Brady, Report 'Challenger' Copepoda, p. 78, pl. 5. figs. 7–16.

1892. *Phyllopus bidentatus,* Giesbrecht, Pelagische Copepoden, p. 419, pl. 18. figs. 25–33, pl. 38. fig. 35; and 1898, p. 124.

The occurrence of an example of this species in 600 fathoms in the Faroe Channel is certainly most interesting. The specimen agrees in minutest details with the figures of Brady and Giesbrecht in mouth-organs, in the 1st and following feet, Giesbrecht (figs. 30 and 31); and above all in the characteristic and remarkable fifth foot of female (Brady, fig. 12; Giesbrecht, fig. 25). The single type was taken by the 'Challenger' in 2650 fathoms in the South Atlantic (lat. 36° 44' S., long. 46° 16' W.), while that figured by Giesbrecht was from 1800 metres in the tropical Pacific (lat. 3° S., long. 99° W.); and now it turns up in the Faroe Channel. It would be difficult to find a case which demonstrated more completely the vast range over which those animals may be distributed which find an equalized temperature in the depths of the ocean. The free-swimming life of the Calanoida of course conduces to their wide distribution, and that they have very wide distribution is also proved by the many other instances of hitherto supposed southern forms

which are in these brief notes now proved to reach those out-
lying waters of the Arctic Ocean which fill the cold depths of
the Faroe Channel.

Another very interesting case of distribution is that of *Amallo-
phora magna*, T. Scott. This was described by Prof. G. O. Sars
in his account of the Crustacea obtained by Nansen in his
Arctic voyage, under the name *Scaphocalanus acrocephalus* ; and
he wrote of it as " one of the most characteristic Calanoids of
the Polar Sea," and " as one of the commonest forms collected
both at the surface and down to 300 metres " ; it, moreover, was
among the species from the most northern gathering (lat. 85°
13' N., long. 79° E.). This species Sars has now found to be a
synonym of *Amallophora magna*, T. Scott, the types of which
were collected in the tropical Atlantic (Gulf of Guinea) in only
20 fathoms (!), and is recorded by Giesbrecht under the name
Scolecithrix cristata from the North, but not arctic, Pacific
Ocean, lat. 35° N., long. 125° W.

Fam. METRIDIIDÆ.

Genus METRIDIA, *Boeck*.

METRIDIA LONGA (*Lubbock*).

1854. *Calanus longus*, Lubbock, ' Some Arctic Species of Calanidæ,' Ann.
& Mag. Nat. Hist. ser. 2, vol. xiv. (1854) p. 127, pl. 5. fig. 10.

1864. *Metridia armata*, Boeck, Oversigt Norges Copepoder, Christ. Vid.-
Selsk. Forhand. 1864, p. 238.

1892. *Metridia longa*, Giesbrecht, Pelagische Copepoden, p. 339, pl. 33.
figs. 9, 13, 20, 23, 27, 34, 38 ; and 1898, p. 106.

1902. *Metridia longa*, G. O. Sars, Crustacea Norway, p. 112, pls. 75 & 76.

Baffin's Bay and Faroe Channel.

METRIDIA LUCENS, *Boeck*.

1864. *Metridia lucens*, Boeck, *l. c.* p. 238.

1878. *Metridia armata*, G. S. Brady, Brit. Copep. vol. i. p. 42, pl. 2.
figs. 1–12, pl. 56. figs. 19, 20.

1892. *Metridia hibernica*, Giesbrecht, *l. c.* p. 340, pl. 33. figs. 2, 12,
16, 22, 28, 36, 39.

1898. *Metridia lucens*, Giesbrecht, *l. c.* p. 106.

1902. *Metridia lucens*, G. O. Sars, *l. c.* p. 113, pl. 77.

Faroe Channel, and 40 miles N.N.W. of Achill Island, Ireland,
200 fathoms.

METRIDIA NORMANI, *Giesbrecht.*

1892. *Metridia Normani,* Giesbrecht, Pelagische Copepoden, p. 340, pl. 33. figs. 1, 6, 24, 25, 30; and 1898, *l. c.* p. 107.

The types of this species were found by Herr Giesbrecht among some *Metridia longa* which I sent him from the Faroe Channel, and Prof. Sars has now detected a single specimen in the gathering made by Prof. Haddon in 200 fathoms off Achill Island, Ireland.

METRIDIA PRINCEPS, *Giesbrecht.*

1892. *Metridia princeps,* Giesbrecht, *l. c.* p. 340, pl. 33. figs. 3, 18, 35, 40; and 1898, *l. c.* p. 107.

Lat. 62° 6′ N., long. 55° 56′ W., ' Valorous ' 1875.

Genus PLEUROMAMMA, *Giesbrecht.*

PLEUROMAMMA ROBUSTA (*Dahl*).

1893. *Pleuromma robusta,* Dahl, Zoolog. Anzeiger, no. 415.

1898. *Pleuromamma robusta,* Giesbrecht, *l. c.* p. 110.

1902. *Pleuromamma robusta,* G. O. Sars, Crustacea Norway, p. 115, pls. 78, 79.

Faroe Channel, tow-net down to 600 fathoms; and 40 miles N.N.W. of Achill Island, Ireland, towing-net at 200 fathoms.

Fam. HETERORHABDIDÆ.

Genus HETERORHABDUS, *Giesbrecht.*

HETERORHABDUS NORVEGICUS (*Boeck*).

1872. *Heterochæta norvegica,* Boeck, Christ. Vid.-Selsk. Forhand. 1872, p. 40.

1898. *Heterorhabdus norvegicus,* Giesbrecht, *l. c.* p. 115.

1902. *Heterorhabdus norvegicus,* G. O. Sars, *l. c.* p. 118, pls. 80., 81.

Forty miles off Achill Head, Ireland, 220 fathoms.

Fam. PONTELLIDÆ.

Genus ANOMALOCERA, *Templeton.*

ANOMALOCERA PATERSONI, *Templeton.*

Faroe Channel.

Fam. ACARTIIDÆ.

Genus ACARTIA, *Dana.*

ACARTIA CLAUSI, *Giesbrecht.*

1892. *Acartia Clausi,* Giesbrecht, *l. c.* p. 507, pl. 30. figs. 2, 4, 13–15, 17, 28, 36, 37, pl. 42. fig. 32, pl. 43. figs. 3, 5, 14; and 1898, *l. c.* p. 152.

Faroe Channel.

Isokerandria, *Giesbrecht*.

Fam. O N C Æ I D Æ.

Genus ONCÆA, *Philippi*.

ONCÆA CONIFERA, *Giesbrecht*.

1892. *Oncæa conifera*, Giesbrecht, Pelagische Copepoden, p. 591, pl. 47.
      figs. 5, 15, 21, 23, 28, 31–38, 55, 56.
1902. *Oncæa conifera*, Giesbrecht, Expedition Antarctique Belge 'Belgica,'
      1897–1899, Zoologie, Copepoden, p. 41, pl. 13. figs. 7–11.

Here is another species of very wide distribution. Described
from Mediterranean specimens, it was found by Sir J. Murray
in the 'Triton' Expedition of 1882, in the Faroe Channel down
to the depth of 500 fathoms, and now Giesbrecht announces it
as having been collected in the Antarctic Ocean by the Belgian
Antarctic Expedition of 1897–1899.

? ONCÆA MEDIA, *Giesbrecht*.

1892. *Oncæa media*, Giesbrecht, *l. c.* p. 591, pl. 47. figs. 1, 11, 29–33, 40.

An *Oncæa* taken by the 'Triton' in the Faroe Channel, and
which I had sent to Prof. Sars marked " *Oncæa media* ?," was
sent back marked in his own writing " ? *Oncæa media*," so that
it must be regarded as a doubtful inhabitant of the locality
given.

Genus CONÆA, *Giesbrecht*, 1891.

CONÆA RAPAX, *Giesbrecht*.

1892. *Conæa rapax*, Giesbrecht, *l. c.* p. 605, pl. 48. figs. 50–59.
1894. *Oncæa gracilis*, T. Scott, Entomostraca Gulf of Guinea, Trans. Linn.
      Soc. ser. 2, Zool. vol. vi. (1894) p. 116, pl. 13. figs. 4–12.

A single specimen in the Faroe Channel at a depth of
600 fathoms. Giesbrecht's type specimens were taken in the
tropical part of the Pacific Ocean down to 4000 metres. Next
it was taken in the tropical Atlantic (Gulf of Guinea), and now
it turns up in the cold area of the Faroe Channel. Had it been
found at great depths in the Gulf of Guinea, we might have
supposed that though living over so large a range, it yet inhabited
water of nearly equal temperature; but Mr. Scott tells us that
the specimens which came under his observation were taken at
various depths, ranging from the surface to 360 fathoms. It is
possible that these may be closely allied species confused, but
the posterior antennæ and posterior foot-jaws of the female are
very remarkable.

On the Life-History of a New *Monophlebus* from India, with a Note on that of a *Vedalia* predaceous upon it. With a few Remarks on the *Monophlebinæ* of the Indian Region. By E. P. STEBBING, F.L.S., F.E.S.

PART I.—*Remarks on the Monophlebinæ of the Indian Region.*

THE *Monophlebinæ*, a subfamily of the Coccidæ, are a group of scale-insects about whose habits little until recently was known in India. In fact, up to 1901 but five species of the genus *Monophlebus* had been recorded from the Indian Region, and of this number four were described from the male insect alone, the females being still unknown. The discovery by the writer in 1901 of both the males and females of two new species was therefore of some interest and importance, but what is perhaps of equal value is that the life-history of one of them has been to some degree worked out, and its habits during one portion of its existence carefully and accurately noted. The species discovered in 1901 were sent to Mr. E. Ernest Green, Government Entomologist, Ceylon. Two were respectively named by him *Monophlebus Stebbingi* and *M. Dalbergiæ*, whilst a third, of which the females only had been procured, was provisionally named *M. Tectonæ*, the material proving insufficient for correct identification. In the following year further forms of this genus were discovered. One, of which both male and female were procured, was determined by Mr. Green as *M. Stebbingi*, var. *mangiferæ*. Others were discovered by the writer in Madras upon teak, *Anogeissus latifolia*, and *Terminalia tomentosa*. Only female specimens were taken, and these have yet to be dealt with, as also has a species which appears to be very numerous in Sind, but of which only the females have as yet been found, and another, reported as living upon the mango in Tirhoot and Dharbanga, in Bengal. It is a curious point about the genus that all the female insects yet discovered have a great resemblance to one another, being whitish oval thick scales. The determination of the species therefore requires the discovery of the males.

Present observations point to the subfamily confining itself to the woody portion of trees and shrubs only, feeding upon the leaves and green twigs in the younger larval stages. In forest-regions it can, as will be subsequently shown, increase in vast numbers, and is thus a source of considerable danger to the trees it infests. In this connection it will be profitable to consider shortly the food-plants and distribution of the at present known species of the genus in the Indian Region. We have seen that previously to 1901 but five species had been named; and four of these, *M. atripennis*, Klug, *M. Burmeisteri*, Westw., *M. Leachii*, Westw., and *M. Saundersi*, Westw., from the male insect only. The excessive feeding and consequent damage is the work of the female, the male being a minute two-winged insect in its adult form, with no mouth-parts. Consequently, in the case of four out of the five species known before 1901, the food-plants are unknown. The fifth bears the name *M. zeylanicus*, and was discovered by Green feeding upon the trunks of *Antidesma Bunius* at Punduloya in Ceylon. Of the three species (one at present doubtful) added in 1901, *M. Stebbingi*, whose life-history, so far as at present known, is treated of in this paper, lives upon the woody branches of the Sâl-tree (*Shorea robusta*, Gaertn.) in the Siwalik Hills and adjacent areas to the west of the Jumna River and east of the Ganges; *M. Dalbergiæ* upon those of the Sissu (*Dalbergia Sisso*, Roxb.) in the Sutlej Valley in the N.W. Himalayas; whilst *M. Tectonæ* (?) feeds upon the teak-tree (*Tectona grandis*, Linn.) in Berar and the Central Provinces. The additional species discovered in 1902 require further study. *M. Stebbingi* var. *mangiferæ* feeds upon mango trees in orchards in the Shalimar Gardens near Lahore and in the Public Garden at Bareilly. A species also lives upon mango in the Tirhoot State in N. Bengal, and at Dharbanga. This insect (or insects, if the Bengal one is a different species) is not unlikely to cause serious loss to fruit-growers when numerous, since the large amount of sap absorbed from the branches and twigs has an injurious effect upon the setting of the fruit *. Females of undetermined species have been obtained from the *Prosopis spicigera* in Sind (by Mr. F. Gleadow), and from teak,

* In a letter just received (12th May, 1903) from Lahore a correspondent informs me that the coccids are more plentiful than ever this year at Shalimar, and that the inflorescences of the mango trees have been seriously affected by their attacks.

Anogeissus latifolia, and *Terminalia tomentosa*, by the writer in the Coimbatore Forests of the Madras Presidency.

From the above notes it will be seen that the genus has apparently a fairly general distribution throughout the Indian Region, being, however, as yet unreported from Assam and Burma. The boundaries may be roughly taken to be as follows:— The Sutlej Valley at a point some 50–70 miles N.E. of Simla in the North-West Himalayas for the northern, with Punduloya in Ceylon as the southern limit, whilst on the west we have a species reported from Sind. The eastern boundary is the most vague. I have received specimens of *M. Stebbingi* from Philibhit, and the mango variety of this scale is to found at Bareilly. But since these insects were obtained, a *Monophlebus* has been procured from Tirhoot and Dharbanga, and this must be looked upon as the present eastern limit. I have myself little doubt, however, that this limit will soon be passed as our knowledge of the genus increases.

PART II.—*On the Life-History of* Monophlebus Stebbingi, *Green* (Indian Museum Notes, vol. viii. p. 100).

(Pl. **16**. figs. 1–13; Pl. **17**. fig. 1; Pl. **18**.)

After this brief summary of the information at present available on the known species and distribution of the genus *Monophlebus*, a more detailed consideration may be given to one of the species, *M. Stebbingi*, with regard to its life-history, portions of which the writer has had exceptional opportunities of studying.

Early in January 1901, whilst on tour in the Sâl Forests of the Siwaliks, soon after my arrival in Upper India, some minute little yellow specks upon the underside of Sâl-leaves were pointed out to me by Mr. J. W. Oliver, Director of the Imperial Forest School, Dehra Dun, as an insect, supposed to be an aphis or scale, which later in the year appeared in great numbers [*]. The yellow specks were the young larval forms of a *Monophlebus*, subsequently named by Green *M. Stebbingi*. From that date

[*] I found that this scale had been known for some years to Planters and Forest officers serving in the Dun, but no attempt had been made to study its life-history. A few specimens of the immature female had apparently been sent to the Indian Museum by Mr. F. Gleadow in 1900, and he had been told that they were immature forms of a *Monophlebus*, but much too small to do anything with. This was the position of affairs in January 1901.

onwards till the end of April, I watched the growth of the scales, sending mature specimens of the male and female (taken by myself personally in the forest) to Green at the end of April. The succeeding year I was able to study the insect again from the middle of January till the middle of May, whilst the following season I watched the younger stages from their first appearance in November until near the end of February. The insects were late in appearing in 1900–01, owing to wet cold weather, but were earlier by several weeks in the seasons of 1901–02 and 1902–03. During the last four or five years the weather seems to have been on the whole most favourable to the development of the pest, which has appeared in ever increasing numbers, and has spread into forests previously reported as free from it. In 1902 the attack was upon a very large scale, the woods over the infested areas literally swarming with the fat white female coccids. It was during this year that the predaceous *Vedalia* beetle was first noticed at work. During the past winter of 1902–3, the young scale again appeared numerously upon the leaves of the trees, and the long spell of intensely cold though excessively dry weather appeared to be favourable to the development of the young larvæ, which were very numerous up to the middle of February, when my observations ceased owing to a transfer to Calcutta.

As seen early in the cold weather (November), the insect is a minute little coccid covered with white woolly hair. It is to be found at this period on the leaves of the Sâl-tree. The little larva soon loses this hirsute covering, and is then yellow in colour, changing to an orange or yellow-brown. At this stage it is still less than 1·5 mm. in length. A fortnight later the brown colouring becomes more pronounced, the scale being then about 2·08 mm. in length, long-elliptical, convex dorsally, and flat beneath, with a longish proboscis, a pair of black antennæ, and three pairs of black legs. After a fourth period of fifteen days has elapsed, the larvæ are about 6·25 mm. in length, dark brown on the dorsal surface, changing to orange or pale canary-yellow in the older specimens; ventral surface canary-yellow; proboscis, antennæ, and legs black. There is a fringe of hairs round the margin (Pl. 16. fig. 2). This colouring remains much the same until the animal reaches maturity, but the whole of the upper surface becomes, when the scale is about half-grown, covered with a white mealy powder.

The male larva is not yet known. The male pupal case is small, dark brown in colour, elliptical, but with a curious fan-shaped flattened expanded portion at one end, rather like the caudal appendage of a fish. This pupal case would appear to be only the last larval chitinous covering, since the leg and antennal cases are attached to it (Pl. **16.** figs. 3 & 4). The pupal skin ruptures at the anterior end—the male insect crawling out of the elliptical opening thus produced. The length of the pupal case is 4 to 4·2 mm. The perfect insect is a small black-winged fly. Both sexes mature in April. Green describes the male and female insects as follows:—

" *Monophlebus Stebbingi*, Green. Indian Museum Notes, viii. p. 100.

"Adult ♀ [Pl. **16.** figs. 5, 6]. Robust. Margins somewhat flattened and forming a distinct lateral keel; median dorsal area tumescent; division of segments well-defined. Colour slaty-grey, thickly dotted with white mealy powder. Legs and antennæ black. Margin with irregular fringe of longish black hair; the whole ventral surface covered with a short pubescence, denser on the margin and intersegmental regions. Both dorsum and ventral surface with numerous circular pores, some with single, some with double orifice, the orifices guarded by small raised points. Antenna with eight joints: first seven subequal in length, third sometimes longer, eighth longer than previous two together; all the joints with many blackish hairs. Legs stout, spiny: tarsus short, scarcely half the length of the tibia: claw long and stout, with a pair of simple hair-like digitules. Anal aperture on dorsum, at some distance from extremity, surrounded by a group of stout hairs. Length of early adult females (taken *in coitû* with the male) 8·50 mm. Breadth 4·50 mm. Older examples attain a considerably larger size. The largest I have examined measures 13 mm. by 8·50 mm., and it is possible that others may exceed these dimensions.*

" Adult ♂ [Pl. **16.** fig. 7]. Dull red: notal and sternal plates black: the whole body dusted with mealy powder, giving it a pruinose appearance; a lunate pale patch in the centre of the mesonotum and a pale space between the mesonotal plates and the scutellum. Legs and antennæ black: wings fuscous, corrugated, with two white creases, one on each side of the discal

* The writer has specimens in his possession of as much as 18·75 mm. and over.

nervure. Halteres with five stout hooked bristles at extremity. Antennæ 10-jointed : 3rd–9th each with three nodes, 10th with four nodes ; each node with a whorl of long hairs. Eyes large, compound ; a single ocellus on the dorsal surface at inner margin of each eye. Abdomen with three elongate fleshy hairy processes on each side ; the first shortest, the third longest. Genital sheath not projecting beyond the posterior margin of abdomen : penis usually partially everted, densely clothed with short reversed hairs. Length 5 mm. Expanse 11·50 mm."

A noteworthy characteristic of the female is the great difference in size of the individuals, and it would appear that it becomes sexually mature before reaching its full dimensions.

Egg (Pl. 16. fig. 1) : small, dry, shining, oval-elliptical. Colour pink : length 1 mm.

When they first appear the minute scales are to be found on the under surface of the Sâl-leaves, and very shortly after hatching they cluster round the mid and other ribs of the leaf, either on the upper or under surface, but more usually on the latter, their probosces being buried in the tissues of the rib. When they have somewhat increased in size, and after losing the white hair with which they commence life, they confine themselves to the mid-rib alone, and then undergo a first moult. From the first the coccids exude a sticky sugary liquid which coats the leaves, and the little white papery skins of this first moult remain stuck by means of this to the leaves, and thus serve to attract the eye to the presence of the insect. The female larva appears to spend from 6 to 8 weeks feeding in this way upon the leaves. The scale is not stationary, but moves about over the leaf and from leaf to leaf. It almost certainly gets spread by the agency of other insects and spiders, and probably also by birds. The sticky exudation doubtless greatly facilitates this dispersion, since animals crawling over or fluttering amongst the leaves and twigs of badly infested trees would unavoidably take up to a certain extent portions of it, and with it a few of the young scales. The habit which this insect possesses, in common with most scale-insects, of crawling over every obstacle in its path, even over its predaceous enemies, which it seems quite unable to recognize, doubtless also helps in its diffusion.

After from 6 to 8 weeks spent upon the leaves, the period depending upon the favourableness or otherwise of the season, the young scale descends to the twigs, and during the rest of its

developing-stage it lives and feeds upon these. Soon after this change of position a further moult is gone through. Moulting takes place as follows :—The skin becomes ruptured anteriorly at a horizontal line of cleavage just above the insertion of the antennæ, the split extending to the first segment of the thorax on either side. At the same time, from a central point in this horizontal line of cleavage a further rupture occurs in a vertical plane, the split reaching a median point in the posterior edge of the metathorax dorsally (Pl. 16. fig. 8), and to the centre of the coxæ of the anterior pair of legs ventrally (Pl. 16. fig. 9). This cleavage having taken place in the chitinous covering, the insect crawls slowly out. Consequently, as a reference to fig. 9 will show, on the under surface of the old discarded skin the black empty leg and antennal cases are to be found. These cast skins remain gummed by the sugary secretion to the twigs (Pl. 16. fig. 11), the insects moving off to fresh ones.

When numerous, the young coccids collect in clusters round the twigs, covering thickly the thinner barked ones (Pl. 16. fig. 10). They are also to be found at wounds on older and thicker branches. When they first quit the leaves the scales are about 3·12 mm. in length. From then onwards their growth becomes more rapid, at least one more casting of the skin takes place, and they mature toward the end of March or middle of April. They change their position and walk about over the trees more often as they begin to reach their full development. It is after this last moult that they acquire the white powdery covering, and if the insect is at all numerous the twigs and branches will be seen to be closely encircled with serried white masses, often for a length of 6–9 inches, of the coccids, giving them the appearance of being encrusted with snow, the scales lying one upon the other, often one tipped up at an angle and resting upon a companion below as depicted in Pl. 17. fig. 1 and Pl. 18, *a*. Each has its proboscis firmly imbedded in the cambium layer, and spends its time sucking in the sap of the branch. I have mentioned that the insects are active throughout life and march about over the trees, and this habit is perhaps more especially noticeable in their later stages of development, when their whitening appearance renders them more conspicuous. When mature, they are to be seen crawling down the trunks of the Sál-trees, these latter being often thickly dotted with the fat white scales.

I have alluded to the sugary excretion. This is poured out very copiously during the whole of the developing-period up to the time of fertilization, soon after which the scales cease feeding. This sticky sugary liquid, which rapidly dries in the hot sun, covers leaves and twigs, clogging up the stomata, runs down the branches, and drips to the ground below in enormous quantities when the insects are plentiful. This feature will be referred to later on as it is of some importance.

The male larva has not yet been found. I was successful in discovering what undoubtedly were pupal cases. In some instances dead male insects, half emerged from the cases, were secured. They were found in the interstices of the rough bark of a felled Sâl-tree, protected by being placed on the portion lying adjacent to the ground. The male insect matures about the middle of March in favourable seasons, and may be seen on the wing for some weeks, possibly as long as a month, until the female scales have all or almost all matured. It is by no means so abundant as the female, and later it pairs with several of these. It is a very active creature, flying about over the serried masses of the coccids or walking over the backs of the thick clusters. Its method of fertilizing the female is as follows:—The male flies or walks lightly up to the female scale, which is probably engaged in sucking up the sap of a twig, alights or climbs on to her dorsal surface, and then forces itself under her between her ventral surface and the twig. It then inserts its anal appendages into the anal aperture of the female, thus becoming attached to her, and remains so attached even if she moves about. When *in coitu* the male may be facing in the opposite direction to the female, lying upon its back so to speak, or it may curve its body up and over the anal segment, clinging with its anterior legs to the dorsal surface of the last segments of the female scale. It remains attached usually for several minutes.

After fertilization the female scales appear to cease feeding, leave the twigs, and march down the trees in search of convenient places to oviposit. It is at this stage more especially that badly-infested forests appear to be alive with the insects— trees, undergrowth, soil, stones, and dead fallen leaves being covered with the crawling coccids. A few days would appear to suffice for the eggs to develop within the body of the female; the females oviposit during the latter part of March and on through April, the actual period depending upon the favour-

ableness or otherwise of the year to insect life. Before the
eggs are actually extruded from the body of the female, the
posterior ventral segments are seen to be developing a white
woolly hair. This increases in amount, especially towards the
anal extremity, and this white woolly mass serves as a second
covering for the eggs. At first this white cottony material is
quite short and, looked at from the dorsal aspect of the insect,
it is seen to project only a little way beyond the tip of the
abdomen.   It, however, rapidly increases in amount until the
insect appears to have a small wad or ball of pulled-out cotton-
wool attached to its abdominal segments, protruding all round
from the ventral surfaces of the three posterior segments.
A closer examination of this cottony mass will show that it really
surrounds a fine cotton sac which encloses the eggs (Pl. **16**.
figs. 12 & 13). Countings I have made of these latter show
that a female lays between 400 and 450 eggs. The greatest
number counted in a sac was 478. Before actually extruding the
sac from the body, the scale leaves the upper part of the tree
and searches out some nook or cranny beneath the rough bark,
or a sheltered spot beneath stones, refuse wood, &c., and con-
ceals herself. After the eggs in the cottony sac have been
extruded from the body, little but the skin remains, the insect
dies, and the dead shrivelled skin remains as a partial covering
to the eggs. Egg-laying would appear to last from a fortnight
to three weeks, after which both the male and female insects
disappear from the forest. I have noted that the eggs at times
are not deposited in particularly sheltered places, and there can
be little doubt, I think, that they get blown about a good deal by
the wind, and carried about by hairy spiders, large lizards, the
feathers of birds, and in the hair of mammals such as deer,
rodents, &c.

There are one or two remarkable features resulting from the
presence of this insect in large numbers in a forest. One is the
enormous exudations secreted by the insects. They appear to
be little more than siphons, and their excretions cover the
branches and trunks of the trees and undergrowth and stones,
leaves, &c. upon the ground beneath with a coating of a sticky
nature, which dries like varnish in the sun. So great is the
amount of sap taken from the trees, that in the silence of the
forest these exudations can be heard dropping from the tall trees
like raindrops after a smart shower. One's clothes and exposed

parts of the body become covered with the unpleasant sticky liquid, and half-an-hour's walk through an infested forest reduces one to a condition of great discomfort. This state of affairs, in years favourable to the increase of the insect, may last from early in January until well on into April.

Another peculiarity about the female is its power of dropping from great heights without harming itself. The smart pat of scales falling from the branches of the tallest trees is to be continually heard on all sides. They appear generally to fall on to their ventral surface, and out of numbers examined I never found one instance in which the scale appeared to have suffered injury or even inconvenience from its great drop. Whether the coccids allow themselves purposely to fall, or whether they get pushed off the branches by companions, I am unable to say, but their habit of feeding so close together would certainly cause their displacement at times. This point is of importance, since it undoubtedly helps in spreading the insect, which is by no means a fast walker.

A third interesting point—one common to all great increases in insect pests, but perhaps especially remarkable in the case of this very noticeable white scale—is the change that a few days will make in the aspect of an infested area. The contrast which eight days will show in this particular case is wonderful. On the one day when the attack is reaching or has reached its culminating point, the forest may be seen to be alive with the insects. Eight days afterwards a scattered few may still be seen crawling about, but the great mass have disappeared, and one seems to be in quite a different locality. The female scales, however, can never be said entirely to disappear from the area. It is generally possible to find a few right on through the months of June, July, August, and September. These may be unfertilized females which developed very late, but I have not been able to account for them satisfactorily. Further, in 1902, after the insects had practically completely disappeared from the forest, I found in several places some young scales, canary-yellow to brown in colour, and from 2·08 to 3·12 mm. in length—in fact, at the age and size usually found in late January and early February. I have not been able to account for finding these.

I have not yet discovered the insect which develops from the eggs laid in such numbers by the female scales. There may be

a second stage in the life-history of the insects, as in the case
of *M. zeylanicus* of Ceylon, but this has yet to be proved. The
branches of the Sâl-trees in the forests which are infested by
these coccids have curious knotty swellings on them, which I
have never seen elsewhere in India upon this tree, and this may
be due to a second subcortical stage of the *Monophlebus*.
My observations on this point are, however, not as yet
complete.

Periodicity of Attack.—This coccid has been known for some
years in the Siwalik area, but it is only since 1899 that attention
has been seriously drawn to it. Each year since then it has
steadily increased in numbers and spread outwards, until in
1902 there was no part of the Siwalik area between the Jumna
and Ganges rivers that was not affected, and it was to be found
both west and east of this tract.

Distribution.—This scale has at present only been reported
from Northern India. Its known habitat is (beginning from the
west) the small Kalesar forest situated on the western bank of
the Jumna river in the plains at the foot of the Himalayas.
From here the insect crosses the Jumna, and is found throughout
the Sâl areas of the Dehra Dun plateau and the Siwalik range of
hills, on both north and south aspects, as far as the Ganges
river on the east. It is also plentiful in the patches of Sâl
forest between the Ganges and Jumna rivers, which extend
into the plains south of the Siwalik range. To the east of the
Ganges its distribution has not as yet been fully determined.
I have specimens (identified by myself) and reports of it from
the Garhwal and Philibhit districts. It is also plentiful in the
Kheri Sâl-forests of Oudh. The area which it is at present known
to infest may therefore be taken as a strip of country extending
some 300 miles from west to east, and 100 miles wide in a north
and south direction on its eastern limit, tailing-off to a 10-mile
strip at its western boundary. I have, however, little doubt
that it will be found to the east of its at present reported limit.

Over all the infested area this coccid, from its excessive
vitality and the great numbers of eggs which the female is
capable of laying, must be looked upon as a serious pest to the
Sâl-tree, one of the most valuable of the trees of India, dis-
tributed over a large tract of the continent. It therefore follows
that the careful study of the life-history and distribution of the

pest is of the first importance, in order that an endeavour may be made to prevent its spreading into Sâl areas at present free from it, and that species of like character, in the event of their only too probable occurrence, may be dealt with in the light of acquired experience.

Present observations show that the female is the chief aggressor; but it must be borne in mind that it has yet to be proved that there is not a second subcortical stage which is likely to do much injury to the trees. The damage arising is due to the heavy loss of sap the trees suffer owing to the continual tapping for several months on end. In the cold weather months from November to February this is perhaps not serious, since the insect is then feeding upon the old leaves. The sap is down and growth has probably ceased, and the clogging of the stomata by the excreted fluid is perhaps the most serious effect at this period. The injury really begins to become acute when the coccid has got down to the twigs. The heavy loss of sap resulting from its attacks at this stage cannot be otherwise than most serious in months when the tree requires all its vitality to enable the spring leaf-buds to develop perfectly and the flower-heads fully to mature. It is just at this period, the most dangerous one for the tree, that the attack of the *Monophlebus* is culminating. Experiments have been commenced with the object of discovering:

    (i.) The effect upon the development of the spring crop of leaves of a bad infestation by the coccids;

    (ii.) The effect of the same upon the maturing and vitality of the seeds.

The attacks are more severe in dry years, since the scale is then in greater abundance.

The damage attributable to the insect may be summarized as follows:—

(*a*) The clogging-up of the stomata and pores of the leaves and twigs by the sugary secretion. This envelops leaves and twigs, &c. with a sticky film which dries in the sun, giving them the appearance of having been varnished. If the year is a wet one the film is rapidly dissolved off by the rain, but in dry seasons it remains for several months *in situ*.

(*b*) Twigs and small branches dry up and die off under the excessive tapping. This latter occurring in the spring has a most serious effect upon the development of the spring crop of

leaves, and upon the flower-panicles which open in April. The production of the seed is thus probably considerably interfered with.

(c) The damage caused to young saplings is perhaps even more serious, as the insects congregate round the leading shoot and the upper side ones, extending down each for several inches in a serried encircling mass. The leading shoot is often killed, and side ones taking its place follow suit, and the young sapling takes on a crooked habit of growth most detrimental to its future value as a forest tree.

Pl. **18**, *a*, shows the female scales collected on a young sapling in this manner.

It may be interesting to note that in the 1901 attack the scale was accompanied over a portion of the Dun Sâl areas by the larva of *Boarmia selenaria*, Hübn., a geometrid moth. This larva was in thousands, and devoured the Sâl-leaves in the most voracious manner. In fact all the green parts of the tree—leaves, buds, the green shoots of the year, together with the white inflorescences—were eaten down, nothing but the blackish last year's growth being left. The larvæ (Pl. **18**, *b*, *b*) can be seen in characteristic attitudes on the upper part of the tree, which they had stripped bare of all green growth. The scales are collected lower down upon the leading shoot in a serried mass.

In the sugary secretion emitted by the scales, a black fungus develops and envelops the leaves and twigs, and doubtless helps further to clog up the stomata. Dr. Butler, Cryptogamic Botanist to the Government of India, has informed me that much of this fungus belongs to the genus *Capnodium*, which is almost always associated with scale-insects. The *Capnodium* was present in three other forms :—

> (a) *Cladosporium*, Link (syn. *Fumago*, Pers.).
>
> (b) *Triposporium* sp.,
>
> (c) *Coniothecium* sp.;

these three being conidial stages in various species of *Capnodium*.

Part III.—*On the Life-History of* Vedalia Guerinii, *Crotch,*
predaceous upon M. Stebbingi, *Green.*

Vedalia Guerinii, *Crotch, Rev. Coccinell.* p. 282 (Lond.
1874). (Pl. 17. figs. 2–9.)

The following are my descriptions of the larva and pupa, made
from living specimens :—

Larva.— When young the larva is black in colour, with three
pairs of stout thoracic legs. During its first two moults it
appears to retain this colour, being long and narrow with a well-
developed head and mouth-parts. As it grows in size it becomes
more oval, and the colour changes to white and black or reddish
with white markings or a greyish purple. The grub is often
covered with a certain amount of the white powdery material
which covers the older stages of the *Monophlebus* upon which it
feeds. The young larva has a number of tubercles upon its
dorsal surface. When full-grown the larva is 12·5 mm. long,
and has a well-developed head, which is narrower than the ten
segments of the body which follow it. Of these latter, the
middle ones are the broadest, the grub tapering to each end.
On each of these ten segments there are four dorsal tubercles,
two on each side, thus giving four rows of dorsal tubercles.
These segments are also fringed on either side by projecting
teeth-like processes resembling a saw-edge, giving the insect a
serrate appearance at the sides. The last two segments make
up the dark reddish-black pad-like apparatus which terminates
the body, the end of which forms a kind of sucker which is very
adhesive and enables the larva to cling to the smoothest bark by
its means. The sucker is used in feeding, and also in fixing
itself permanently to a twig or leaf before changing to the
pupal state (Pl. 17. fig. 4 *a*). The arrangement of the segments
makes the body extremely pliable, and the grub can roll itself
up almost into a ball. The ventral surface is coloured like the
dorsal aspect, but has no tubercles. Just before pupating the
larva often changes from the white and black or greyish-purple
colour to a brick-red.

Pupa.—When about to pupate, the larva attaches itself either
to the upper or under surface of a leaf or to a twig or rough
bark by means of the posterior adhesive pad, its body projecting
at an angle from the point of attachment, and assuming a curved

position, the dorsal surface being convex, ventral concave (fig. 4 a). The larva remains in this position for about 24 hours, and then the outer skin splits dorsally from the anterior end to the posterior portion of the 10th segment, and the skin gets drawn or shrivels back on either side, and the bright red, almost spherical, pupa is disclosed (figs. 4 b & 5). The pupa, nestling in the surrounding purple and white speckled old larva-skin, looks not unlike a small wild strawberry fruit sessile amongst the leaves. In the crimson pupa the two small black eyes of the future beetle, the developing wings, and dorsal segmental divisions of the abdomen can be distinctly seen under the brightly coloured skin. The posterior segment of the future beetle is nearest to the point of attachment of the pupa, so that when the adult coccinellid is ready to emerge, the skin splits dorsally and ventrally at the anterior end of the pupa, and the beetle crawls out. Size 6·25 mm. The colour varies from bright to dull red, crimson, or orange-red.

For the imago, *vide* Crotch's description in his 'Revision of the *Coccinellidæ*,' p. 282 (1874).

In both its larval and adult stages this *Vedalia* preys upon the coccid *M. Stebbingi*.

It was found in its larval, pupal, and imago forms in large numbers in the Siwalik Forest in April 1902.

The exact period passed in the larval stage has yet to be observed, but the grubs in that year commenced pupating towards the end of March, and continued to do so till the end of April. Eight to nine days appear to be the usual period spent in the pupal stage. Larvæ pupating on the 16th April issued on the 24th and 25th of the month, and numerous other individuals bred out showed this period to be fairly constant. The beetle passes some days, perhaps as much as a fortnight, feeding upon the scales before pairing and ovipositing. The male adult dies within 24 hours of fertilizing the female; this latter then apparently seeks out a place of concealment before depositing her eggs. These eggs have not yet been discovered, though dead beetles have often been found in interstices of bark, beneath stone and débris on the ground, &c., near the dead shrivelled skins and cottony egg-sacs of the *Monophlebus*. It would appear probable that they lay their eggs in the places wherein those of the coccids are deposited.

The larva is a very active grub, and when in search of its

prey it is to be found running at a great pace over the leaves, twigs, and bark of the trees. During this portion of its existence the insect is not gregarious. The larva is a voracious feeder, and preys upon the large white succulent female scales with the greatest avidity. Its method of operation is as follows :—

On perceiving a scale it rushes at it with great impetuosity and at once fixes its mouth-parts in the soft skin, often on the ventral surface between the first and second pairs of legs and a little to one side. At the same moment it attaches itself to the twig by its terminal adhesive pad. The scale at first makes no movement, but after the lapse of a minute or two ceases feeding (if it were engaged in that operation at the time of attack) and commences slowly moving its antennæ and legs, at first lazily, as is its habit when crawling about, but later more vigorously. As it does this, a bright canary-yellow stream of liquid flows down from its body onto the twig. This exudation from the wound continues for about three to four minutes, after which it ceases, the rest of the material being absorbed by the larva, who has by now his mouth-parts firmly fixed into the coccid. This latter now makes vigorous though unwieldy attempts to get away, and being so much larger than the grub, often even as much as thrice its size, it at times stretches out its enemy to its full length, the segments under the tension becoming much elongated. The latter, however, keeps its position on the twig by means of its sucker-pad with the greatest ease. Practically only the mouth, first pair of legs, and sucker-pad are made use of, the first being buried in the body of its victim, the second clasped round it, the third attached to the twig. The 2nd and 3rd pairs of legs are held backwards almost against the ventral surface of the body (fig. 7). Under this sucking process the formerly robust powdery-white succulent scale shrinks gradually to a shrivelled, wizened, dried-up, yellowish-brown skin. The larva's mouth consists of a tube terminating in a swollen knob where it joins the head, the latter being greenish-yellow in colour. This probably acts in the nature of a sucker as well, since it exerts considerable leverage upon the scale. Larvæ watched feeding have spent between eight and nine hours clinging to and sucking a scale, at the end of the period only the shrivelled skin remaining. The vitality of the *Monophlebus* is very great, since at the end of six to seven hours

of this continued tapping process on the part of the grub it is
still alive, slowly moving its legs and antennæ. This object-
lesson in the insect world has to be seen and watched to be
properly appreciated. At first sight it would appear incredible
that such a small larva as the *Vedalia* should be capable of
entirely absorbing the contents of an insect of the size of the
Monophlebus, and the curious point about this absorption is that
the grub shows little signs of having assimilated this large
amount of food-material. There is very little distension of the
segments, and I could observe very little excretion taking place
during or after this heavy meal. The grub is very active, and
must be possessed of an exceedingly rapid digestive system.
It would be of great interest to study its digestive organs
with the object of discovering whether it gets rid of excreta
in any manner through the skin.

I have mentioned the great voracity of the grub, and my
observations led me to discover that it has cannibalistic pro-
pensities, for I found it preying upon pupæ of its own species.
This may have been due to a shortness in the food-supply. It
dashes on the pupa with its usual impetuosity, seizes it round
the crimson spherical portion with its two anterior legs, fixes its
mouth-parts into the soft tissues beneath the skin, and sucks
out the contents, leaving the crimson skin empty in a very short
time (fig. 8 *a*).

The larva is parasitised by a hymenopterous or dipterous fly.
Larvæ in the first stage of pupation, *i. e.* before the skin splits
down disclosing the crimson pupa, were noticed to have a dried
appearance. An examination showed several, as many as five
in some instances, small round holes, evidently the exit-holes of
a parasite (fig. 8 *b*). This insect, while it decreases the number
of future beetles, does not appear to prevent the larva destroying
a number of scales, since it has strength to pupate before suc-
cumbing to the parasite. I have not as yet discovered this
parasite.

When about to pupate the *Vedalia* grub becomes gregarious,
the pupæ being often found in numbers close together on the
upper or under side of leaves or twigs &c. This habit was too
marked to have been due to accident. The beetles are very
gregarious. During the heat of the day, when they do not feed,
they are to be found in large numbers collected close together

on the underside of leaves—Sâl, *Bauhinia*, and other large leaves
being those usually affected.   The adults also feed upon the
female *Monophlebus*, attacking them in a similar manner to
that of the grubs and anywhere on their dorsal or ventral
surfaces (fig. 9).   They do not, so far as my observations showed,
fly up and alight upon a scale, but usually crawl up to it and
then make a short rush.   In feeding they pierce through the
skin, and a drop or two of the yellow liquid comes out, but never
a stream.   They do not kill their host outright, as they appear
to be full-fed in half an hour (and often do not remain more
than five to ten minutes), by which time they have absorbed but
a small quantity of the body-contents.   Whilst the beetle is
feeding upon it, the scale either continues to remain with its beak
buried in the tissues of the Sâl-twig or it may move about with
the beetle attached to it, but it does not appear to be incon-
venienced to any great extent, and only shows signs of feeling
when the beetle first pierces through the skin.   The scales
would, however, appear to be killed off in time, or to have their
vitality greatly reduced, through this constant tapping by
different beetles.   Individuals which have been so tapped show
numbers of small white and yellow spots, the places at which the
beetles have pierced them.   They lose their fresh white powdery
appearance, become much shrivelled, are dirty brown or whity-
black in colour, and move about very slowly.   It is probable
that those which do not die under this constant sapping of their
body-contents are so reduced in vitality that their egg-laying
capacity becomes considerably impaired, and even if eggs are
laid, their fertility is probably doubtful.   The female *Vedalia*
would appear to commence oviposition at about the same time
as the *Monophlebus*.

A careful study of this attack showed me that the *Vedalia*
did not begin to multiply in any serious proportions until the
female scale had undergone its third moult.   The numerous
empty white papery skins of this moult, attached by the sticky
secretion in large numbers to every twig and branch, were
evidence of the fact that the coccid had reached this stage of
development before its decimation commenced.   These skins re-
mained *in situ* upon the branches for several weeks owing to the
exceptionally dry year experienced in 1902, practically no rain of
importance falling during this period.   A single heavy thunder-

storm, such as are usually experienced at that season, would at once dissolve the sticky excretion covering the branches and remove all evidence of the preceding moults, and thus the state of affairs in progress would not be so clearly decipherable as it was in the year in question. The forests were a truly remarkable sight about the middle of April. Larvæ, pupæ, and adults of the *Vedalia* were everywhere: the former running agilely over the trees in quest of their prey; the pupæ being collected in numbers on leaves and twigs, more especially perhaps on the former; whilst the large leaves of the trees were weighed down by the red masses of the beetles clinging to their under surfaces during the heat of the day, as these latter only feed in the early morning and evening. On every side also were dried shrivelled skins of the sucked-out scales, gummed to the branches or bark of the trees, stuck in the interstices of the bark of the latter, or littering the ground amongst the dead leaves, &c. Away aloft the crowns of the great Sâl-trees appeared to have their extremities encrusted with snow from the numbers of the scales clinging to and feeding on the sap of their twigs and smaller branches, and this incrustation was repeated on the branches of the smaller trees and saplings, whilst the crawling coccids invaded every corner of one's tent and covered the leaf-littered ground without.

DESCRIPTION OF THE PLATES.

PLATE 16.

Monophlebus Stebbingi, Green.

Fig. 1. Eggs.
    2. Young ♀ scale-insect, dorsal view.
    3. Side view of ♂ pupal case.
    4. Ventral view of ♂ pupal case.
    5. Full-grown ♀ scale, dorsal view.
    6.   ,,   ,,   side view.
    7. Winged ♂ insect.
    8. Cast skin of immature ♀, dorsal view.
    9.   ,,   ,,   ventral view.
  10. Immature ♀ feeding upon a young Sâl-twig.
  11. Cast skins of immature ♀ attached by the sugary secretion to a Sâl-branch.
  12. Ventral view of ♀ with cottony egg-sac and eggs.
  13. Dorsal view of ♀ with cottony egg-sac.

MONOPHLEBUS STEBBINGI, Green.
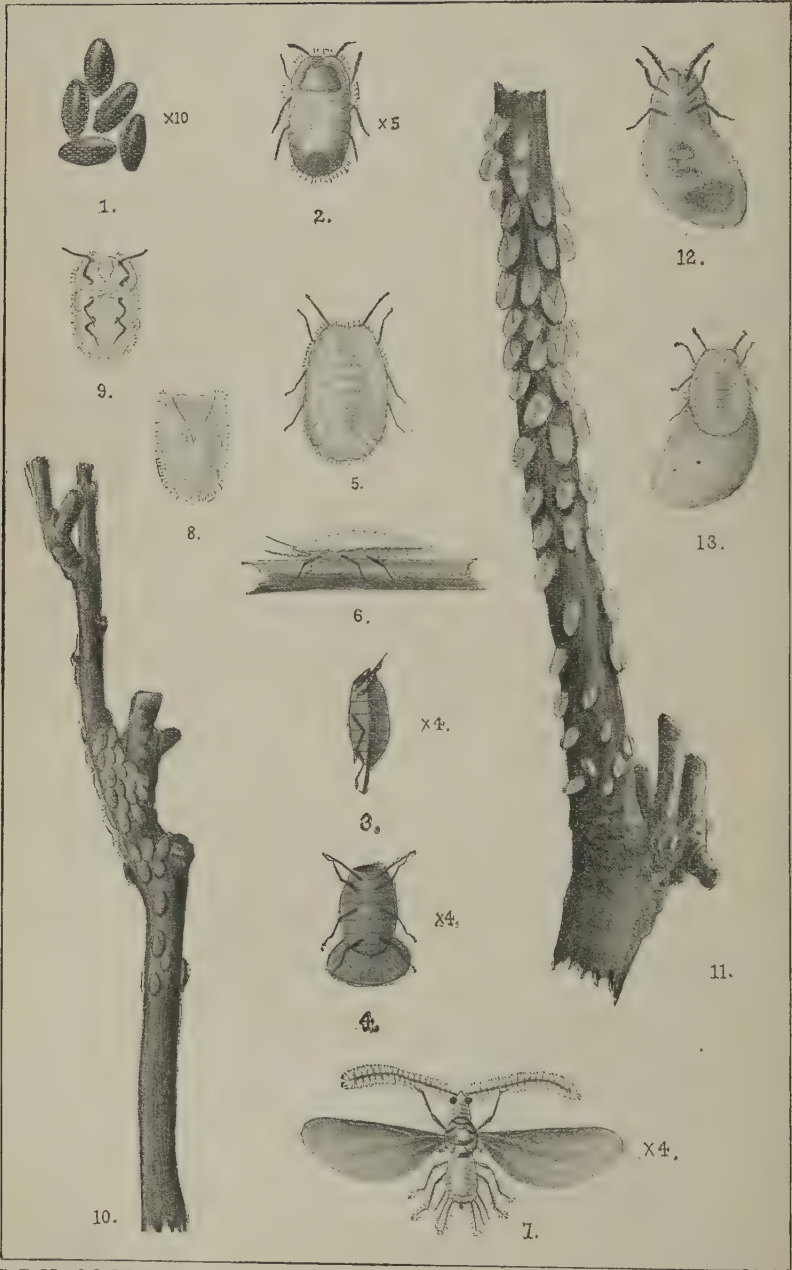
S. B. Mondul, del.

T. P. Collings, photosc.

MONOPHLEBUS STEBBINGI, Green, and
VEDALIA GUERINII, Crotch.

MONOPHLEBUS STEBBINGI, and
BOARMIA SELENARIA, Hübn.

PLATE 17.

M. Stebbingi, Green, and *Vedalia Guerinii*, Crotch.

Fig. 1. Sâl-branch with fully mature ♀ scales feeding (from a drawing by Author).
  2. Larva of *Vedalia Guerinii*, dorsal view.
  3.   ,,   ,,   side view.
  4. Sâl-twig with (*a*) pupating larva, (*b*) sessile pupa, upon it.
  5. Pupa of *V. Guerinii*, sessile, upon a Sâl-leaf.
  6. Beetle.
  7. *Vedalia* larva attacking ♀ *Monophlebus*-scale.
  4. Sâl-twig with (*a*) *Vedalia* pupal skin after having been attacked by *Vedalia* larva, (*b*) larval skin after attacks of parasites.
  9. *Vedalia* beetle attacking ♀ *Monophlebus*-scale.

PLATE 18.

Upper portion of a Sâl (*Shorea robusta*) sapling, showing the attacks of *Monophlebus Stebbingi*, Green (below), and of the larvæ of *Boarmia selenaria*, Hübn. (above). From a photograph by Mr. R. C. Milward, I.F.S.

NOTE.—Small numbers against the figures give the enlargement. Unfortunately all the Plates, in reproduction, had to be reduced by about $\frac{1}{15}$th. This reduction will therefore have to be allowed for to obtain the true sizes of the figures shown.

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Bryozoa from Franz-Josef Land, collected by the Jackson-Harmsworth Expedition, 1896–1897.*—Part II. Cyclostomata, Ctenostomata, and Endoprocta. By ARTHUR WM. WATERS, F.L.S.

[Read 17th March, 1904.]

(PLATES 19–21.)

THE Cyclostomata are, on the whole, unreliable guides in questions of geographical distribution, for, as we all must recognize, the classification of this suborder is unsatisfactory, although in course of time the examination of the anatomy of the living forms may lead to a natural classification being established. The uncertainty concerning the classification of the Cyclo-

* Continued from Vol. xxviii. p. 105.

stomata arises, in the first place, from the small number of readily available characters, but some of the confusion results from the fact that so many attempts at classification have been based upon fossils; and here almost valueless characters have been used, in consequence of which very exaggerated ideas as to the number of Cretaceous and other fossil Cyclostomata have been received.

Formerly, in the Chilostomata generic divisions were based upon the zoarial form, but now the zoœcial characters are known to be of chief importance, and the zoarial shape is hardly ever of more than specific value, though there may be exceptions, such as the Catenicellidæ. On the other hand, in the Cyclostomata a large number of species and genera have been, and are still, based entirely upon the shape of the zoarium; and until other characters have been made available these groupings must continue to be used, to enable us to record what has been met with, even though these may be catalogue genera and not natural genera.

The number of characters available can be increased; and since Smitt published his papers on the Northern Bryozoa, the importance of the ovicell in the classification of the Cyclostomata has been more fully recognized. Smitt was, moreover, the first who gave a number of figures of ovicells of Cyclostomatous Bryozoa. In my papers I have always referred to the ovicells where there was suitable material, and have dealt with some in two communications *, and since then Dr. S. F. Harmer has published a most valuable series of papers on the embryos and ovicells of *Crisia* †, *Lichenopora* ‡, and *Tubulipora* § ; and it is now fully established that useful classificatory characters are furnished by the position and shape of the ovicell, as well as by the nature of the oœciopore. We must see how far the number of tentacles is of value; then the position and form of the closures || are other useful characters; and there are ovarian and sexual characters which must be examined, such as the size

* "On some Ovicells of Cyclostomatous Bryozoa," Journ. Linn. Soc., Zool. vol. xx. p. 275; and "On the Ovicells of some Lichenoporæ," *op. cit.* p. 280.

† Quart. Journ. Micr. Sci., n. s. vol. xxxii. pp. 127–181, pl. 12.

‡ *Ibid.* vol. xxxix. pp. 71–144, pls. 7–10.

§ *Ibid.* vol. xli. pp. 73–157, pls. 8–10.

|| "Closure of the Cyclostomatous Bryozoa," Journ. Linn. Soc., Zool. vol. xvii. (1884) pp. 400–404, pl. 17.

and number of the embryos and the way in which the embryo is formed. The position in the zoœcium from which new zoœcia grow will certainly here be of value, just as it is in the Chilostomata; for on this the shape of the colony sometimes depends, and this colonial shape must always receive attention. In many species there are internal denticles having distinct forms.

It is too often forgotten that we cannot be sure of genera until we have established the characters upon which the species are based, and then satisfactory family-groups may be made; but at present the attempts to group into families are often ridiculous.

I have been able to examine the ovicells and embryos of *Diastopora intricaria*, Smitt, and *Hornera lichenoides*, Pontop.; but on the whole the collection did not contain many species with ovicells, or with them in such condition or abundance as to admit of much examination.

Since the first part of this communication was published, in this Journal, the following papers on the Arctic Fauna have appeared:—

Bidenkap, Olaf: "Die Bryozoen von Spitzbergen und König-Karls Land," Fauna Arctica, vol. i. pt. ii., 1900. Andersson, K. A.: "Bryozoen während der Schwedische Expedition 1898–1899–1900 gesammelt," Zool. Jahrb. vol. xv. 1902, pp. 537–560, pl. 30. Norman, Canon A. Merle: "Notes on the Natural History of East Finmark—Polyzoa," Ann. & Mag. Nat. Hist. ser. 7, vol. xi. pp. 567–598; vol. xii. pp. 87–128 (1903).

Norman, in his paper, puts my *Schizoporella Harmsworthii* under *Lepralia Smitti*, Kirchenpauer; but I still consider that the name *Harmsworthii* should stand, for though this species has been seen before, it has been described mixed up with other species. Smitt figured under *Escharella Legentilii*, forma *prototypa*, two species; and when Kirchenpauer gave the name *L. Smitti* he referred to all of Smitt's figures 47–52, thus including Smitt's forma *typica*, which belongs to another genus, and is probably *Smittia reticulata*, MacG. Kirchenpauer then refers to Smitt's synonyms, those mentioned being *Smittia reticulata* or closely-allied forms, and says they do not correspond with the *L. Smitti*; but all the same it seems impossible to know what Kirchenpauer had before him, as he gives no description. When describing *S. Harmsworthii* I gave my reasons for the new name, and only referred to Smitt's figures 47–48, as fig. 49

12*

must belong to another species; however, Norman includes figs. 47–49.

The present paper was practically written, and the drawings for the plates prepared, before I commenced the examination and description of the collection from the Antarctic made by the 'Belgica,' but it was kept back for comparisons to be made with the Antarctic fauna. The collection alluded to proved to be a very considerable one, containing 86 Antarctic forms besides a few Subantarctic. Of the Antarctic forms, 57 are considered new; but although the number of new species is so large, many of them are closely allied to known forms from the Southern hemisphere, the greatest resemblance naturally being with Subantarctic and South Temperate forms. No species of the Chilostomata is considered to be identical with Arctic forms.

There are 15 species of Antarctic Cyclostomata, and for the most part they are not satisfactory, as few contain ovicells; but nearly all of them, or close allies, have a very wide range of distribution, and three have been found in the Arctic, but these three may all be considered cosmopolitan.

The Bryozoa, so far as they are known at present, certainly do not seem to give any support to the Bipolar theory; but as I have entered more fully into the geographical distribution in my memoir * on the Antarctic Bryozoa, it is not necessary to deal with it here. I have also in the same work protested against the use that has been made of the term Antarctic, when Subantarctic was meant, for, until the last few years, our knowledge of the Antarctic fauna has been most scanty; nevertheless, long lists of animals have been drawn up and called Antarctic, whereas they really were Subantarctic. By including Subantarctic with Antarctic, the area is made about twice as large as that which we call Arctic. Comparisons thus made have to be set aside, but no doubt before long a complete comparison of the Arctic and Antarctic faunas will be possible, as the various Expeditions may be expected to bring back important collections.

There was only one species of Ctenostomata brought back by the Belgian Expedition; however, it was interesting, as we know so few *Alcyonidia* from the Southern hemisphere, but the species described by me makes the third from the extreme south. They all have numerous tentacles, whereas most of the European ones have only 13–17 tentacles.

* Résultats du Voyage du S. Y. 'Belgica' en 1897–1898–1899: Bryozoa, 1904.

1. CRISIA CORNUTA, var. GENICULATA, *M.-Edw*.

Crisia cornuta, var. *geniculata*, Hincks, Brit. Mar. Polyzoa, p. 419, pl. lvi. fig. 44.

All the specimens of *Crisia* from Franz-Josef Land are only fragmentary, and are without ovicells, so that we can add nothing to our knowledge of the genus, but only record the localities.

There has been a doubt whether *geniculata* should be considered as a variety or as belonging to another genus (*Crisidia*), for in *C. cornuta* the spines are not found to all the zoœcia—in some cases to very few. Harmer * however considers, from differences in the ovicell, that *C. cornuta* and *C. geniculata* should be specifically separated. In Smitt's and other works the locality for the two varieties is not given separately, and therefore a full list of the distribution cannot be made, but I do not find that this variety has been recorded from Arctic seas.

Loc. British. Naples.

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 55° 25′ E., 115 fath.

2. CRISIA EBURNEO-DENTICULATA, *Smitt, MSS*.

Crisia eburnea, var., Smitt, Öfvers. Vet.-Ak. Förh. 1865, p. 142, pl. 16. fig. 9.

Crisia eburneo-denticulata, Busk, Brit. Mus. Cat. Mar. Polyzoa, pt. III. p. 5, pl. 6; Vigelius, "Cat. of Polyzoa coll. during Cruises of the Willem Barents," Niederl. Archiv. f. Zool., Suppl. p. 4.

Although there are no ovicells, I think there can be no doubt that the specimens belong to the species described by Busk. The zoarium is narrow, the zoœcia from the two sides being very close together without an intermediate space; there are about 11–17 zoœcia to an internode; the joints are light; the free end of the zoœcia is short, and the branches start from the lower zoœcia.

Loc. Spitzbergen, 70–90 fath.; Barents Sea, 150 fath.

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 5° 20′ E., 130 fath.; 50 miles N.W. of Cape Mary Harmsworth, 234 fath.

3. CRISIA EBURNEA (*Linn*.).

There are a few fragments from Günther Sound which seem to be the lower joints of this species. There are about six

* Harmer, "On the British Species of *Crisia*," Quart. Journ. Micr. Sci., n. s. vol. xxxii. p. 170.

zoœcia to an internode, with fresh branches given off from about the second zoœcium.

IDMONEA.

Gregory, in his 'Catalogue of Cretaceous Bryozoa,' p. 150, would do away with *Idmonea* as we now understand it, and would restrict it to "Idmoneidæ with the zoarium adnate." He does this taking *I. triquetra*, Lamx., as the type, which is stated by Gregory to be adnate. Lamouroux's figures in 'Exposition Méthodique des Polypiers,' pl. 79. figs. 13 & 14, however, seem to be drawn from an erect species; and in his description of the genus *Idmonea* Lamouroux says: "altera facie subcanaliculata," showing that he had before him a free zoarium, and no doubt most, if not all, workers have taken the description as referring to an erect form.

4. IDMONEA ATLANTICA, *Forbes.* (Pl. 21. figs. 2, 3.)

Idmonea atlantica, Smitt, "Krit. Fört.," Öfvers. Vet.-Ak. Förh. 1866, pp. 399 & 434, pl. 4. figs. 5–9; Hincks, Brit. Mar. Polyzoa, p. 451, pl. 65. figs. 1–4; MacGillivray, Tert. Polyzoa Victoria, p. 122, pl. 16. fig. 17, pl. 17. fig. 8; Bidenkap, "Bry. Spitzbergen," Fauna Arctica, vol. i. p. 527; Waters, Résultats du Voyage du S. Y. 'Belgica': Bryozoa, p. 90, pl. 9. fig. 5.

For other synonyms Miss Jelly's Catalogue may be consulted; but I feel considerable doubt as to whether the name has always been correctly applied, and although we call it Forbes's species there is uncertainty as to any determinations previous to Smitt, and perhaps he would have done better by giving it a new name. The branching is much less frequent than is shown in Johnston's figure, and the dorsal surface is usually concave, though it is sometimes convex as described by Johnston. The colonies grow to a considerable size, evidently two or three inches in height. There are usually three zoœcia in a series, which are about 0·9 mm. to 0·1 mm. apart, and the closure occurs at a short distance from the base of the erect portion. The bifurcation is nearly always a broad distinct curve, as figured by Smitt; then the branches run nearly parallel. The aperture of the zoœcia is about 0·15 mm. wide. Unfortunately both Busk and Hincks fail to give the magnification of their figures, so that no comparison of size can be made.

In the specimens from Franz-Josef Land the ovicell does not

occur at a bifurcation, but is a central inflation, involving one or two series of zoœcia. In most of the few ovicells found the ovicellular duct cannot be distinguished; but in one, though somewhat broken down, it is seen as a narrow opening close up to the zoœcial tube. Busk figures the ovicell in his British Museum Catalogue, but does not refer to it, whereas Hincks describes but does not figure it. Smitt figures an ovicell at a bifurcation, but as his figure relates to an "Alecto stadium," we cannot be sure whether he has seen the ovicell of *I. atlantica*, nor can we be sure of the localities from which he obtained his *I. atlantica*.

A more delicate form has been described as var. *tenuis*, and it is not always certain whether the variety is referred to. The 'Challenger' specimen from Simon's Bay is more delicate than the common Arctic form.

Loc. Spitzbergen (*Bidenkap*); Barents Sea; Kara Sea; Jan Mayen, 15–180 metres; Scandinavia; Greenland; Finland; Novaya Zemlya; British coasts; Florida; Japan, 200 fath.; and Busk, in the 'Challenger' Report, gives Nightingale Island; Kerguelen; Cape of Good Hope; Cape Horn Exp.: Station unknown (*Waters*), Antarctic, lat. 70° S., long. 80° 48′ W., 500 (?) fathoms.

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 53° 20′ E., 130 fath., and lat. 77° 55′ N., long. 53° 16′ E., 130 fath.; 50 miles N.W. of Cape Mary Harmsworth, 53–93 fath. and 234 fath.

5. IDMONEA FENESTRATA, *Busk.*

Tubulipora fenestrata, Smitt, "Krit. Fört." 1866, p. 399.

Idmonea fenestrata, Bidenkap, "Bry. Spitzbergen," Fauna Arctica, vol. i. p. 528.

There is a worn specimen which I think is the species referred to by Smitt. It is a stout form, frequently branching, with the solid dorsal part much wider than the front, and with wide lines on the dorsal surface. Three or more zoœcia to a series, which are confined to the front part of the zoarium.

A question has been raised as to whether the *I. fenestrata* of Busk and of Smitt are identical.

Loc. Spitzbergen (*Smitt*; and *Bidenkap*, 100 metres).

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 53° 16′ E., 130 fathoms.

6. IDMONEA TUMIDA (*Smitt*).   (Pl. 21. figs. 4, 5.)

Tubulipora (*Idmonea*) *tumida*, Smitt, " Krit. Fört." 1871, p. 1119, pl. 20. fig. 7.

Idmonea atlantica, var. *tenuis*, Busk, Rep. Brit. Assoc. 1859, p. 146.

There is one specimen from Franz-Josef Land which is about 20 mm. long, but it is broken at each end; about 5 mm. from the lower end of the piece it divides into branches, dividing again after about 19 mm. The branches do not spread out widely, in this respect resembling *I. atlantica*, Forbes; they are about 0·6 mm. wide, and the series are about 0·7 mm. apart, while the zoœcia are about 0·1 mm. internal diameter. It will be seen that the branches are much narrower than those referred to under *I. atlantica*, Forbes, and the series are much closer together.

The *I. atlantica*, var. *tenuis*, Busk, has not been figured or fully described; but in all probability this is the species that has been frequently alluded to as var. *tenuis*, though, as the zoœcia are so much narrower, it would seem correct to consider it a separate species.

Loc. Smeerenberg, Spitzbergen (*Smitt*).

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 53° 16′ E., 130 fathoms.

7. HORNERA LICHENOIDES (*Pontop.*).   (Pl. 20. figs. 1–6.)

Besides the references given in Miss Jelly's Catalogue, see Bidenkap, " Bryozoen von Ost-Spitzbergen," Zool. Jahrb. vol. x. 1897, p. 632, pl. 25. fig. 4; id. Lyngenfjordens Evertebratfauna, 1899, p. 94; id. " Bry. von Spitzbergen und König-Karls Land," Fauna Arctica, vol. i. pt. III. p. 529; Nordgaard, " Die Bry. des West Norwegens," Meeres-Fauna von Bergens, p. 100; Gregory, J. W., The Cretaceous Bryozoa, vol. i. 1899, p. 361, fig. 44; Andersson, K. A., " Bry. während der Schwed. Exp. 1898–1900 . . . . gesammelt," Zool. Jahrb. vol. xv. pt. II. p. 551, 1902.

This is an Arctic form which Busk gives as off Monte Video ('Challenger'), and Kirkpatrick as from Port Phillip, and it has been stated to have been found in the Antarctic *; but I have in various places stated that there is reason for considering that a mistake in labelling has been made. A closely-allied species, however, occurs in the Antarctic, which I have named *H. antarctica*, Wat. Miss Jelly gives *H. ramosa*, MacG. †, as a

* To this specimen, reported to have been brought back by the ' Erebus' and ' Terror,' I have already referred, Journ. Linn. Soc., Zool. vol. xxviii. (1900) p. 62.

† MacGillivray, " Description of New or Little-known Polyzoa," pt. XII., Trans. Roy. Soc. Vict. 1886, p. 3, pl. 1. fig. 4.

synonym, but from the description that seems to be a much smaller and more delicate species. However, as *Reteporidea ramosa*, d'Orb., is *Hornera*, MacGillivray's species cannot stand.

A specimen from Naples is very much like the *H. lichenoides*, having similar dorsal ovicells, and has been called *H. lichenoides*; but I propose to separate it as *H. mediterranea*. It has the zoœcia irregularly placed; the outer zoœcia are much the longest, the inner ones are not much raised, and the border is entire. It may be the *H. serrata* of Meneghini, but the name *serrata* has been previously employed by Reuss. *H. borealis*, Busk, from Shetland, has been frequently placed as a synonym of *H. lichenoides*, Pontop.; but I am not confident that this is the case, as I find in an authentic specimen sent to me so named by Canon Norman that the zoœcia are smaller, measuring internally about 0·08 mm., and they are more abundant than in the Arctic *H. lichenoides*. A considerable number of specimens should be examined to see what is the range of variation.

The dorsal position of the ovicell obtains in but few genera, and therefore the comparison with other Cyclostomata has a special importance, as it cannot arise through a slight modification of a zoœcium, though there must at some time have been a communication with a zoœcium; and the adaptive changes must have been much greater than in such genera as *Crisia* and *Idmonea*.

A comparison with the ovaria of *Diastopora intricaria*, Smitt, already described, shows some important differences. In that species we have seen that the number of embryos in an ovicell is very large, being over one hundred, whereas in the ovicell of *H. lichenoides* it would not seem, from my sections, to exceed about ten, and these are much larger than those of *Diastopora intricaria*, probably about four times as large, and these last are much further developed. Ostroumoff* says that the larvæ of *Hornera* are the largest of the marine Ectoproct Bryozoa with which he is acquainted, measuring 0·48 mm., and that in size downwards are *Hornera*, *Tubulipora*, *Frondipora*, *Discoporella*, and *Crisia*, which last are only 0·07 mm. The protoplasmic reticulum is attached to the wall of the ovicell, and not only surrounds the group of larvæ but passes between the individuals,

* "Zur Entwickelungsgeschichte der Cyclostomen Seebryozoen," Mittheil. Zool. Station zu Neapel, vol. vii. p. 180.

and in this protoplasmic reticulum there are a number of large
isolated cells, suggestive of ovarian cells; but at first I could not
find proof of this, though ultimately some groups of these cells
were found so closely resembling the ovaria of various Bryozoa as
to leave no doubt that we have here ovaria formed in or on the
border of the protoplasmic reticulum.

In the Chilostomatous Bryozoa the position of the ovaria
differs according to the species, and the position may often turn
out to be a specific character of some importance: sometimes
it is at the side of the zoœcium, sometimes, in fact frequently,
it is close to the base of the cæcum, but in all cases attached to
the parenchym-tissue. The protoplasmic network spreads to all
parts of the zoœcium, but is usually abundant at the base of the
cæcum, so that some authors have spoken of a funiculus where
it does not exist. Figures are given, for comparison, of an
Alcyonidium (Pl. **20**. figs. 8, 9, 10) in which the ovarium occurs
close to the cæcum, and grows within a separate protoplasmic
network, with large nucleated ova (see p. 180).

It would thus seem as if, while the differences are very great,
there are some points of comparison between the formation of
the ovarium within the ovicell of *H. lichenoides* and within the
zoœcium of some Chilostomata and Ctenostomata; but there
are important questions which my sections do not answer:—Are
the ova fertilized by the spermatozoa within the ovicell? and in
what way is there a connection between the originating zoœcium
and the ovicell?

Until more sections have been made it must remain an open
question, whether this continuous growth of ovarian cells within
the protoplasmic network is supplementary to "embryonic
fission," or in what way it is related to it, for it does not seem to
me to entirely fall in with the description given by Harmer *.

The calcareous wall of the ovicell is formed by thin vertical
bars between the outer and inner surfaces, enclosing spaces; but,
being rather fragile, it is difficult to make sections. The figures
given by Smitt of the dorsal surface of *H. lichenoides* are very
characteristic, but in dried or incinerated specimens the rows of

* Harmer says:—"The primary embryo consists of a mass of embryonic
cells (or rather, nuclei imbedded in continuous protoplasm) which are obscurely
differentiated into outer and inner cells (or nuclei). The whole function of this
embryo is to act as an embryogenic organ, or producer of secondary embryos."
—Quart. Journ. Micr. Sci. n. s. vol. xxxiv. p. 209.

tubular pores do not appear as regular, and then the ridges are seen between the pores.   There are 9 tentacles.

Loc. Very general from the Arctic Regions, also from off the British coast.   Busk, in his 'Challenger' Report, gives *Hornera lichenoides* from off the Argentine; Kirkpatrick mentions it from Port Phillip, and Whiteaves from the St. Lawrence.

Fossil. From the Crag; Victoria (*MacGillivray*); Calabria, Post-Pliocene (*Neviniani*).

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 55° 25′ E., 115 fath., and lat. 77° 55′ N., long. 55° 16′ E., 130 fath.; off glacier between Cape Flora and Cape Gertrude, 30 fath.; 50 miles N.W. of Cape Mary Harmsworth, 234 fath.

8. DIASTOPORA OBELIA, var. ARCTICA, nom. nov. (Pl. **21.** fig. 1.)

Diastopora hyalina, forma *obelia,* Smitt, "Krit. Fört." 1866, pp. 396 & 421, pl. 8. fig. 8.

The characters of the Franz-Josef Land specimens are well represented by Smitt's figure, in which the position of the adventitious tubule is different from that of the British and Mediterranean *D. obelia,* Johnst.

There are large zoœcia the ends of which are erect, and by the side of these is a narrow adventitious tubule, which is the termination of a fairly wide horizontal or erect tube, about half the width of a zoœcium.   In the British and Mediterranean *D. obelia,* the tubule is in a line below the zoœcial aperture, while in the fossil *D. brendolensis,* Waters, the tubule rises up by the side of a zoœcial tube.   It is a question whether the differences mentioned justify the specific separation of the Arctic from the better-known form of *D. obelia.* Smitt and others speak of *D. hyalina,* and *D. hyalina,* forma *obelia,* but from the tables of distribution &c. it is not always possible to know which of the forms is being referred to.

The ovicell extends over the entire distal end of the zoarium, enclosing a very large number of zoœcia (see Pl. **21.** fig. 1). Neither in this variety nor in any specimen of *D. obelia* have I found "closures" of any kind, whereas in *D. sarniensis,* Norm., there is a closure with a narrow tube at the end.

There are 10 tentacles in *D. obelia,* from Naples.

The *Proboscina malaccensis,* d'Orb.,* from the Straits of Malacca, No. 13760, Mus. d'Hist. Nat. Paris, is *Diastopora* with

* Paléontologie Français, vol. v. p. 847.

the tubules by the side of the zooecia opening near the zooecial aperture, as figured by Smitt (" Krit. Fort." 1866, pl. 8. fig. 11). Not having seen any ovicell, or made any measurements of this specimen, it is better not to definitely decide that it is identical with our Arctic variety, although I am aware of no difference. The specimen is discoid. *Berenicea prominens*, Lamx., is not figured or described by Lamouroux or d'Orbigny as having tubules, but in the Paris Museum d'Orbigny's tube 13770 contains *Diastopora obelia* with tubules and another species without, all labelled *B. prominens*.

Berenicea prominens, Lamx., is Gregory's type of *Berenicea*, but *Berenicea* we can only consider as *Diastopora*; and whether it is the *D. obelia*, Johnst., as stated by Gregory, or another *Diastopora* can never be decided by the description or figures, as these would do equally well for most *Diastopora* and for species in other genera as well. Norman * considers that *Berenicea prominens*, Lamx., is *Chorizopora Brongniarti*, Aud., and certainly Lamouroux's figure could not settle the question as to whether *Diastopora* was intended; but when we examine the other two figures of " *Berenicea* " we can hardly doubt that they are *Diastopora*. We thus have two authorities wishing to overthrow two well-recognized genera, *Diastopora* and *Chorizopora*, one believing that *Berenicea prominens*, Lamx., was *Diastopora obelia*, while the other thinks it was *Chorizopora Brongniarti*, Aud.

Canon Norman is perhaps better acquainted with the older literature of the Bryozoa than anyone else, he is a most careful observer, and is known to possess a splendid collection for reference, and therefore we may say that he has given us a most instructive example of the difficulty of trying to make out what the older authors described. We all have to spend too much time in looking back, to find out what was meant when species were described without any of the characters which are now recognized as of greatest importance being used. We should all be better employed in going forwards.

For the species of *Diastopora* with adventitious tubules it may possibly be advisable ultimately to accept a new genus, but the name *Diplopora* † proposed by Jullien & Calvet has already been

* " Natural History of East Finmark," Ann. Mag. Nat. Hist. ser. 7, vol. xi. p. 569, 1903.

† " Bryozoaires provenant des campagnes de l'Hirondelle," Monaco, 1903, p. 115.

used by MacGillivray, and until more is known about the tubules it would seem better to place both groups with *Diastopora*.

Loc. Wäderöarne, Bohus Bay (*Smitt*).

Jackson-Harmsworth Exp.: two-thirds of a mile S.W. of Elmwood, 18 fath., 26th June, 1897; off Cape Mary Harmsworth, 53–93 fathoms.

9. DIASTOPORA INTRICARIA (*Smitt*).   (Pl. **19.** figs. 1–13.)

Reticulipora intricaria, Smitt, Öfvers. Vet.-Ak. Förh. 1871, p. 1117, pl. 20. figs. 1, 2, 3; Nordgaard, O. Mar. Polyzoa, ii. Bergens Museum Aarbog, 1896, p. 5; id. Polyzoa den Norske Nordhavs-Exp. 1876–8, p. 19, pl. 1. fig. 12 (1900); Bidenkap, Bry. von Ost-Spitzbergen, Zool. Jahrb. vol. x. 1897, p. 632; "Die Bry. von Spitzbergen und König-Karls Land," ii. Fauna Arctica, p. 528, 1900.

Diastopora intricaria, Smitt, *op. cit.* 1878, p. 13; Levinsen, Bry. fra Kara-Havet, Dijmphna-Togtets zool.-bot. Udb. 1886, p. 325.

This seems to be one of the commonest species from off Franz-Josef Land, and from these specimens some additions can be made to Smitt's description.   We are, however, at first met with the difficulty as to where it should be placed, for it may be called a bilaminate *Diastopora*, and three names have been given for bilaminate *Diastopora*, namely, *Mesenteripora* (Blainville, 1834), *Reticulipora* (d'Orbigny, 1847), and *Bidiastopora* (d'Orbigny, 1847); but probably all should remain under *Diastopora*, though, should this not be done, then *Mesenteripora* may have to be retained, dropping the others.

However, Gregory *, for the previously recognized genus *Reticulipora* of d'Orbigny creates a new genus *Reticrisina*, but under no circumstances could this new genus be retained. D'Orbigny made the genus *Reticulipora* for some Cretaceous species, describing and figuring four species, though, following the rule adopted throughout his work, he first mentioned any species already described which he considered belonged to the genus, usually giving them in the order of the geological formation to which they belonged, and then he described the new species.   In this case *Apsendesia dianthus* of Blainville is mentioned first, because it comes from the Bathonian of France, but in my opinion this in no way justifies us in saying that this is the type of the genus, and Gregory seems to have misunderstood

* " The Cretaceous Bryozoa," Cat. Foss. Bryozoa in the British Museum vol. i. p. 176.

d'Orbigny when he says " that genus was founded by d'Orbigny in 1849 for the *Apsendesia dianthus* of Blainville, which is a Bathonian species." We now know that d'Orbigny made a mistake in placing the *A. dianthus* under *Reticulipora*, and that it does not at all correspond with his diagnosis of the genus. Taking as the type the species that was first mentioned, because it was geologically the oldest, would add much to the present confusion, as this case demonstrates; for all the *Reticulipora* well described and figured by d'Orbigny are not allowed to remain in his genus, while another species merely mentioned, which does not correspond with his description of the genus, is made the type of *Reticulipora* of Gregory (non d'Orb.) ; and then in Gregory's Catalogue the *Holostoma contingens*, Lonsdale, is placed under *Reticulipora*.

In *Diastopora* the zoœcial tubes are small, whereas in *Stomatopora* they are usually larger with much thicker walls. It is only in *Diastopora* (used in a wide sense) that the " closure " has a small tubule in the middle ; and such closures are now known in *Diastopora sarniensis*, Norm.; *D. concinna*, MacG.; *Reticulipora nummulitorum*, d'Orb.; *R. obliqua*, d'Orb. (Cretaceous) ; *R. papyracea* *, d'Orb. (Cret.) ; *R. dorsalis*, Waters ; *Mesenteripora repens*, Haswell ; *Mesenteripora meandrina*, S. Woods ; *Diastopora gutta*, Jull. & Calvet.

There are a few species which have " adventitious tubules " (*Busk*) called zoœciules by Jullien, as for example *D. obelia*, Johnst.; *D. intricaria*, Smitt ; *D. brendolensis*, Waters ; *Diplopora Grimaldi*, Jull. & Calv. The closures of the species of this group, so far as they are known, have numerous perforations (see Pl. **19**. fig. 7), and to none of the closures is there a tubule. It is unfortunate that the term tubule has been employed in the same genus for quite different structures.

In *D. intricaria* the adventitious tubules arise from the space formed over the groups of zoœcia by a second calcareous layer, as shown in Pl. **19**. figs. 9, 10.

In the adventitious tubules of *D. obelia* there is a protoplasmic † mass, passing through a group of muscles, but this I have not

* This occurs in *R. obliqua*, d'Orb., fossil from Tours and from La Bonneville; and in *R. papyracea*, d'Orb., from La Bonneville.

† Pergens, " Bry. du Crét." Bull. Soc. Belge de Géol. vol. iii. p. 311, fig. 4 ; Waters, " North Ital. Bry.," Quart. Journ. Geol. Soc. vol. xlviii. p. 155.

been able to see in *D. intricaria,* for the material was not favourable, as in most cases the zoœcia were empty and the zoarium was dead.

The flattened branches (Pl. **19.** fig. 2) form an anastomosing network as seen in fig. 1, and evidently the colonies may grow to a considerable size, probably extending to considerably over six inches in length and width. The flattened branches may be considered a series of irregular lobes, with the zoœcia arranged more or less in series, and in some parts the zoœcial tubes are very long, projecting at right angles to a branch (see fig. 5); in other parts the zoœcia do not extend beyond the surface (fig. 8). There are zoœcia on the dorsal (lower) surface of the zoarium (fig. 4). A marked characteristic is the wavy arrangement of the zoœcia, which is well seen in balsam preparations, as well as in sections of the calcareous parts (fig. 13), and such sections show some irregular denticles in the walls.

The ovicells are large and considerably raised (figs. 4 & 6), with the zoœcial tubes in some cases projecting much above the ovicellular wall; in other cases they are at about the level of the wall, as are also the adventitious tubules, while these and the zoœcia both have perforated closures. The ovicellular duct is rather small and does not expand into a funnel, and not more than one has been found to an ovicell. The ovicell, which spreads irregularly between the zoœcial tubes, contains a large number of small embryos; there will usually be more than 100 at the same time (fig. 12).

There are 12 tentacles.

If the broken fragments, from some of the bottles, had been found fossil, they would probably have been arranged under various genera and many species. We have the ends of the branches (Pl. **19.** fig. 3), which quite correspond with Cretaceous *Reticulipora*; some of the fragments of the older part of the flat branches resemble in shape the Crag *Mesenteripora*; and again, pieces with prolonged zoœcial tubes (figs. 4, 5) would have been separated from those in which the zoœcia do not project *.

Loc. Spitzbergen (*Nordg. & Biden.*), 65–300 fath. (*Biden.,*

* That we are still only struggling towards a satisfactory classification of the Cyclostomata may be seen from the fact that Pergens in "Tabl. Syn. de la Classification," Rev. des Bry. p. 326, has placed *Diastopora* under the family Diastoporidæ, *Reticulipora* under the family Idmoneidæ, and *Bidiastopora* and *Mesenteripora* under Entalophoridæ.

8–1000 met.) ; Kara Sea (*Smitt & Levin.*), 35–125 fath. ; Finland (*Nordg.*) ; Baffin's Bay (*Sm.*) ; Norway (*Sm.*), 200–230 fath. ; off Iceland (*Nordg.*); Bear Island (*Nordg.*).

Jackson-Harmsworth Exp. : off glacier between Cape Flora and Cape Gertrude, about 30 fath. ; lat. 77° 55′ N., long. 55° 25′ E., 115 fath. ; lat. 77° 55′ N., long. 53° 20′ E., 130 fath. ; lat. 77° 55′ N., long. 53° 16′ E., 130 fath. ; 40–50 miles N.W. of Cape Mary Harmsworth, 234 fath.

10. STOMATOPORA INCRASSATA, *Smitt.*

From off Cape Mary Harmsworth, 53–93 fathoms, there is a small specimen which is apparently *S. incrassata*, Smitt, but the determination of a small fragment is not satisfactory. The zoœcia are about 0·18 mm. internal diameter.

Loc. Arctic ; British ; Queen Charlotte Island ; Spitzbergen, to 1000 fathoms (*Biden.*) ; Antarctic (*Waters*) ; Gulf of St. Lawrence ; New South Wales (*Waters*).

11. STOMATOPORA sp.

I find myself unable to determine this *Stomatopora*, and consider that a large number of the names of Northern *Stomatopora* are only synonyms. There are many specimens from Franz-Josef Land without ovicells, the lobes are wide, the zoarium is flat, and the ends of the large zoœcia are but little raised. In zoarial growth it most nearly resembles *Tubulipora lobulata*, Hassall ; but why is *T. lobulata*, Hassall, to be generically separated from *Stomatopora expansa*, Hincks, and is not Hincks right in his surmise that this last may be *Proboscina ramosa*, d'Orb. ? *Stomatopora diastoporoides*, Hincks, seems to be separated on very slight grounds. This last, Smitt has called *Diastopora diastoporoides*.

The internal measurement of the aperture of the Franz-Josef Land specimens is 0·13 mm.

12. LICHENOPORA VERRUCARIA (*Linn.*).

Discoporella verrucaria, Smitt, " Krit. Fört." Öfvers. Vet.-Ak. Förh. 1866, p. 405, pl. 10. figs. 6–8, pl. 11. figs. 1–6.

A specimen from Günther Sound, growing on *Flustra*, is typical *L. verrucaria* of Smitt, and also from other localities it occurs, though in less satisfactory condition.

The central portion is covered over by a wall, with openings

of very irregular shape and size, as figured by Smitt (pl. 11. fig. 4) ; through this wall pass the ovicellular ducts with funnel-shaped openings. The zoœcial tubes have the median longitudinal rib well marked, and this usually forms a median acuminate process, though sometimes the two sides are acuminate instead. Typical *Lichenopora verrucaria*, L., occurs from Naples and other Mediterranean localities, though in one form which I at first named *L. verrucaria* the rays are more distinct, and perhaps it is a variety of *L. radiata*, Aud.

Heller, when referring to *Tubulipora verrucaria*, L., gives *Madrepora verrucaria*, Fab., as a synonym, but, judging from the references to Milne-Edwards's and Johnston's figures, it is probable that Heller was describing *Tubulipora flabellaris*, Johnst. He also gives *M. verrucaria*, Fab., as a synonym of his *Discopora hispida*, which may be *Lichenopora hispida*, Flem. *Lichenopora verrucaria*, L., has been very carefully studied by S. F. Harmer, with special reference to the ovicell, and the results are given in his paper " On the Development of *Lichenopora verrucaria*," Quart. Journ. Micr. Sci. n. s. vol. xxxix. p. 71, pls. 7–10. Ridley mentions and figures a closure with a central opening, and thinks that Smitt had mistaken some of these for ovicellular ducts.

Loc. Spitzbergen, 10–65 fath. (*Bid., Nordg.*); Barents Sea (*Vigelius*) ; Jan Mayen, 160–180 metres ; Greenland ; Novaya Zemlya, 5–20 fath. (*Sm.*) ; Kara Sea, 50 metres (*Sm.*) ; Iceland, 15–20 fath. ; Franz-Josef Land, lat. 79° 55′ N., long. 51° 0′ E. (*Ridley*) ; Davis Straits ; Labrador ; Queen Charlotte Islands ; Orca, Prince William Sound ; Alaska (*Robertson*) ; British Seas ; Naples ; Cette, 15–90 metres (*Calvet*) ; Oran, Algiers (*W.*).

Jackson-Harmsworth Exp.: Günther Sound, 10 fath. ; off Elmwood, 18 fath. ; off glacier between Cape Flora and Cape Gertrude, about 30 fath. ; lat. 77° 55′ N., long. 53° 16′ E., 130 fath. ; Bay W. of Cape Flora, 5 fath.

13. LICHENOPORA CRASSIUSCULA (*Smitt*).

Discoporella crassiuscula, Smitt, "Krit. Fört.," Öfvers. Vet.-Ak. Förh. 1866, pp. 406 & 482, pl. xi. figs. 7–9.

There is a specimen from off Cape Mary Harmsworth which resembles Smitt's figures. It has been suggested by Jullien *

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* " Bryozoaire recueillis à Étretat," Bull. Soc. Zool. France, vol. vi. p. 13, 1881.

that Smitt's species is only young colonies of *Lichenopora hispida*, Flem., but this is open to question.

14. CYLINDRŒCIUM DILATATUM, *Hincks*.

There are a few zoœcia of a *Cylindrœcium*, which I believe is *dilatatum* ; but with only a few zoœcia, it is difficult to be quite certain as to the specific determination.

Loc. British and North French coasts ; Bohus Sea ; Jan Mayen (*Lorenz*).

Jackson-Harmsworth Exp.: Lat. 77° 55′ N., long. 53° 16′ E., 130 fathoms.

15. BUSKIA NITENS, *Alder*.

A few colonies growing on Hydrozoa are not sufficient for detailed examination.

Another species of *Buskia* occurs in the Mediterranean, one has been found in the Mergui Archipelago, and one off Cape Horn.

Loc. Davis Straits, 100 fath. (*Hincks*); White Sea ; Barents Sea, lat. 72° 32′ N., long. 36° 29′ E. (*D'Urban*); Queen Charlotte Island (*H.*); Mediterranean (*H.*).

Jackson-Harmsworth Exp.: off Cape Mary Harmsworth, 53–93 fath., and lat. 77° 55′ N., long. 53° 20′ E., 130 fath.

ALCYONIDIUM.

The appearance of *Alcyonidium* is so different from that of most of the Bryozoa, that in all probability it has been frequently passed over, and is more widely distributed than the present records would indicate.

From the Southern hemisphere I only find *Alcyonidium* mentioned a few times—namely, Hincks gives Natal as a locality for *A. gelatinosum*, L., and the 'Challenger' brought one species also from S. Africa, which Busk named *A. flustroides* ; MacGillivray mentions none from Victoria ; but Kirkpatrick gives *A. mytili*, Dalyell, from Port Phillip, and he also described *A. flabelliforme* from the Antarctic, while I have named an Antarctic species *A. antarctica*.

My own studies are but limited, and from my collection I cannot criticise this genus, but we appear to know : —

ARCTIC :—*A. gelatinosum*, L. ; *A. hirsutum*, Flem. ; *A. mamillatum*, Ald. ; *A. mytili*, Dalyell; *A. albidum*, Ald.; *A. corniculatum*,

Sm.; *A. disciforme*, Sm.; *A. disjunctum*, Hincks; *A. lineare*, Hincks; *A. parasiticum*, Flem.

BRITISH. *A. gelatinosum*, L.; *A. hirsutum*, Flem.; *A. mytili*, Dalyell; *A. albidum*, Ald.; *A. excavatum*, Hincks; *A. lineare*, Hincks; *A. parasiticum*, Flem.; *A. polyoum*, Hass.; *A. subviride*, Couch.

MEDITERRANEAN. *A. gelatinosum*, L.: *A. mytili*, Dalyell; *A. duplex*, Prouho.

S. AFRICA. *A. gelatinosum*, L.; *A. flustroides*, Busk.

There has been but little anatomical work done on *Alcyonidium*, but there is one very valuable paper by Prouho, Arch. Zool. exp. ser. 2, vol. x. no. 4, 1892; and Farre, in the 'Philosophical Transactions,' 1837, under the name *Halodactylus*, gives figures of cross sections, but without detail. The zoarial cuticula is very thick, and there is no zoarial wall consisting of large vacuolated cells, as in the Phylactolæmata (see Braem, Davenport, and Kraepelin).

16. ALCYONIDIUM GELATINOSUM (*Linn.*). (Pl. **20**. fig. 7, and Pl. **21**. figs. 6, 7.)

To the list in Miss Jelly's Catalogue, add:—

Alcyonidium gelatinosum, Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. xiii. p. 207; Levinsen, Zool. Danica (Danske Dyr), p. 80, pl. 7. figs. 21–26; Bidenkap, "Die Bryozoen von Spitzbergen und König-Karls Land," Fauna Arctica, vol. ii. p. 530, pl. 10. fig. 6; Robertson, "Bryozoa," Harriman Alaska Expedition, Proc. Wash. Acad. Sci. vol. ii. p. 329.

There are some specimens growing from a thin stalk which is about 12 mm. long and 1–2 mm. wide; at the end of this stalk the cylindrical unbranched colony becomes much wider, to about 20 mm., and in one specimen attains a length of about 100 mm. Levinsen has figured this form in his 'Danske Dyr,' pl. 7. fig. 21, and it corresponds in shape with Bidenkap's figure of *A. hirsutum*, *op. cit.* pl. 10. fig. 5. This group has a white leathery appearance. The other group is frequently branched and lobed, and the specimens never attain to so great a length, being about 25–50 mm. long and about 4–5 mm. in diameter. These specimens look more fleshy and are a dirty grey, and one was figured by Levinsen, Danske Dyr, pl. 7. fig. 22. The external cuticula of this form contains a great quantity of imbedded diatoms and other débris, so that it seems as if the colour depends upon this foreign matter, for in the whiter specimens the diatoms are absent. The cuticula surrounding the colony is fairly thick,

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whereas the walls separating the zoœcia are quite thin. The minute structure has not been considered sufficient to furnish grounds for separating the two forms.

The Franz-Josef Land specimens have 17 tentacles, which seems to be about the number generally found, though Lamouroux and Fleming, apparently in error, say 12 tentacles, Smitt gives 15–17, Farre 16 or occasionally 15, Hincks 15–17. I have published the number of tentacles of other species, but it may be well to repeat the list here. *A. hirsutum*, Flem., has 15–17 (*Hincks*); *A. mamillatum*, 16–18 (*Hincks*); *A. mytili*, Dalyell, 15–18 (*Hincks*), 19 (*Waters*); *A. parasiticum*, Flem., 15–16 (*Hincks*). So that about 17 may be said to be frequently the number in *Alcyonidium*; but *A. duplex*, Prouho, has 20 tentacles (*Prouho*); *A. polyoum*, Hass., 20 (*Hincks*); *A. Brucei*, Calvet, 16–18 (*Calvet*); *A. cellarioides*, Calvet, 20 (*C.*). Hincks gives 18 for *A. albidum*, Alder, whereas Prouho says about 25; *A. variegatum*, Prouho, 28 or more tentacles; *A. flustroides*, Busk, 24–27 (*Waters*); *A. flabelliforme*, Kirkp., 26–28 (*Waters*); *A. antarcticum*, Waters, 24–27. I have sections of a small subglobular specimen from Naples about $\frac{1}{2}$ inch in diameter, growing from a stalk and with a thick cuticula, like *A. gelatinosum*, and in some respects it seems to resemble that species, but it has 24 tentacles.

In sections of specimens of *A. gelatinosum* from off Cape Mary Harmsworth the ovarium (Pl. **20**. fig. 7) is surrounded by small nucleated cells forming a wall the thickness of several cells, and within this are the large ova, of which there are three or four.

In the subglobular specimen from Naples just referred to, the ovarium is in a separate protoplasmic network, with large nucleated ova, and this network of various shapes is distinctly outlined. The ovarium is close to the base of the cæcum, and at first has only comparatively small ova, or rather embryonic cells (Pl. **20**. fig. 8, and the upper part of figs. 9 & 10). The growth of the ovarium in this species should be carefully compared with that of *Hornera lichenoides* and other Cyclostomata. A comparison of Braem's * figure of the ovarium of *Plumatella fungosa* shows great similarity with that of *A. gelatinosum*.

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* " Die geschlechtliche Entwickelung von *Plumatella fungosa*," Zoologica, Heft 23 (1897), pl. 2. fig. 54.

Loc. Spitzbergen; Greenland; Novaya Zemlya; Kara Sea; Jan Mayen; Barents Sea; White Sea; lat. 77° 55′ N., long. 51° ·02′ E. (*Ridley*); Murman and Matochkin Shar (*Stuxberg*); lat. 76° 24′ N., long. 62° 34′ E., 170 metres (*Marenzeller*); Scandinavia; Queen Charlotte Island; Alaska (*Robertson*); British and French coasts; Adriatic (*Hincks*); Natal (*H.*).

Jackson-Harmsworth Exp.: off Cape Gertrude, about 30 fath., the stalked and the lobed form; Günther Sound, 10 fath., the stalked form; Cape Flora, off West Bay, 8 fath., lobed form; ⅔ mile S.W. of Elmwood, 18 fath., lobed form; N. Wilczek Land, 127 fath., stalked form; off Cape Mary Harmsworth, 53–93 fath., lobed form; lat. 77° 55′ N., long. 53° 20′ E., 130 fath., stalked form.

Loxosoma singulare, *Keferstein.*

Loxosoma singulare, Keferstein, Zeitsch. f. wissensch. Zool. xii. p. 13, pl. 11. fig. 29; for other references see Miss Jelly's Catalogue and Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. vi. p. 276; Harmer, Quart. Journ. Micr. Sci., n.s. xxv. 1885, p. 4; Jullien & Calvet, Bryozoaires provenant des campagnes de l'Hirondelle, 1903, p. 28, pl. 2. fig. 5.

There are a few specimens from 50 miles N.W. of Cape Mary Harmsworth growing upon *Diastopora intricaria*, Sm., from 234 fathoms; and *Loxosoma* does not seem to have been previously recorded from so great a depth.

The peduncle is about twice as long as the calyx and is wrinkled transversely: but the material was not sufficient for complete study.

Vigelius found the *L. Nitschei*, Vig., in material brought back by the ' Willem Barents ' Expedition, and Levinsen records an undetermined species from the Kara Sea.

Loc. St. Vaast-de-la-Hougue; off Novaya Zemlya, 62 fathoms; Shetland; Naples; Newfoundland, 155 metres (*Jull. & Calv.*).

Jackson-Harmsworth Exp.: 50 miles N.W. of Cape Mary Harmsworth, 234 fathoms.

Species	Mediterranean	British	Jan Mayen	Gulf of St. Lawrence and Labrador	Barents Sea and Novaya Zemlya	Kara Sea	Spitzbergen	Finland	Greenland	Cape Mary Harmsworth No. 4. 234 fms.	Cape Mary Harmsworth 58–93 fms.	No. 3. Lat. 77° N.	No. 2. Wilczek.	No. 1 Station †	Tentacles	Page
1. *Crisia cornuta*, var. *geniculata*, M.-Ed.	*	*										*				165
2. „ *eburneo-denticulata*, Sm.					*	*	*					*				165
3. „ *eburnea* (L.)	*	*			*	*	*		*					*		165
4. *Idmonea atlantica*, Forbes	*	*	*	*	*	*	*	*	*	*	*					166
5. „ *fenestrata*, Busk					*	*	*					*				167
6. „ *tumida*, Sm.							*					*		*	9	168
7. *Hornera lichenoides* (Pontop.)	*	*	*	*	*	*	*		*	*		*		*	12	168
8. *Diastopora obelia*, var. *arctica*, nov.								*			*			*		171
9. „ (*Reticulipora*) *intricaria*, Sm.					*	*	*		*	*				*		173
10. *Stomatopora incrassata*, Sm.												*				176
11. „ sp.							*				*					176
12. *Lichenopora verrucaria* (Linn.)	*	*	*	*	*	*	*		*			*		*	8 (H.)	176
13. „ *crassiuscula*, Sm.											*					177
14. „ *Cylindræcium dilatatum*, Hincks	*	*	*									*				178
15. *Buskia nitens*, Alder	*	*			*							*				178
16. *Alcyonidium gelatinosum* (L.)	*	*	*		*	*	*		*		*	*	*	*		179
17. *Loxosoma singulare*, Keferstein	*	*			*											181

† The divisions are explained in the first part of this paper, Vol. xxviii. p. 47.

EXPLANATION OF THE PLATES.

PLATE 19.

Fig. 1. *Diastopora intricaria*, Smitt. Dorsal surface of the zoarium. The shape of a lamina is seen at the right-hand side, as it is partly turned sideways. Natural size. From off glacier between Cape Flora and Cape Gertrude, about 30 fathoms. (*ov*) ovicell.

2. Do.; natural size. Two laminæ. From lat. 77° 55′ N., long. 55° 25′ E.

3. Do.; natural size. End of branch, corresponding in shape with Cretaceous fossils figured by d'Orbigny.

4. Do. Dorsal surface, × 12. The ovicell is seen from the side, and to the left there is the extremity of a young lateral branch. From 50 miles N.W. of Cape Mary Harmsworth, 234 fathoms; Aug. 8th, 1897.

5. Do. Anterior edge of a lamina, showing the length of the zoœcial tubes, which extend at right angles to the two surfaces, × 12. Same colony as fig. 4.

6. Do. Ovicell with one oœciostome, and at the upper part of the ovicell the base of a lateral branch is enclosed, × 12. Off glacier between Cape Flora and Cape Gertrude, 30 fathoms; July 21st, 1897.

7. Do. The end of a zoœcium and of an adventitious tubule, both with closures. From the ovicell fig. 6. × 85.

8. Do. Showing the zoœcia with perforated closures, and also the position of the adventitious tubules, × 25.

9. Do. Calcareous longitudinal section, showing the outer calcareous wall beyond the zoœcia, × 25.

10. Do. Transverse section of the same colony as fig. 9, × 25.

11. Do. Section of lobe (*a*) of the ovicell fig. 12, × 85. 50 miles N.W. of Cape Mary Harmsworth, 234 fathoms; Aug. 8th, 1897.

12. Do. Section of ovicell, × 25.

13. Do. Calcareous section showing the irregular wavy position of the zoœcial tubes, also showing small internal projections, × 25.

PLATE 20.

Fig. 1. *Hornera lichenoides* (Pontop.), × 25. Longitudinal section showing the polypides and the ovicell, surrounded by the wall (*w*), from which the reticulum (*r*) has separated, no doubt in consequence of the processes of preservation and preparation. In the reticulum, on the left-hand side, some ovarian masses are seen, and these are more magnified in fig. 4. Six embryos are seen in the section. From lat. 77° 55′ N., long. 55° 25′ E., 115 fathoms; July 8th, 1897.

2. Do. Transverse section of ovicell, × 25. From lat. 77° 55′ N., long. 53° 20′ E., 130 fathoms; July 13th, 1897.

3. Do. Section of embryo, × 85. Whether the cilia on the upper part are in two tufts or are continuous is not clear.

Fig. 4. *Hornera lichenoides*, L. Section of protoplasmic reticulum containing ovarian masses, × 450. This reticulum is shown slightly magnified in fig. 1.

    5. Do. Section of the wall of the ovicell, × 100.

    6. Do. Do., × 250.

    7. *Alcyonidium gelatinosum*, L. Ovarium showing three ova surrounded by the follicular walls, × 250. From Cape Mary Harmsworth, 53–93 fathoms ; Aug. 8th, 1897.

    8. *Alcyonidium* sp. Younger end of the ovarium, × 250. From Naples. This species corresponds in most particulars with *A. gelatinosum*, L.

    9. Do. Young ovarium attached to the cæcum, × 250.

    10. Do. Ovarium in a distinct reticulum, × 85.

PLATE 21.

Fig. 1. *Diastopora obelia*, var. *arctica*, nov., × 25. Showing the adventitious tubules and the ovicell. From ⅔ of a mile S.W. of Elmwood, 18 fathoms ; June 26th, 1897.

    2. *Idmonea atlantica*, Forbes. Natural size.

    3. Do. × 12. Showing the ovicell. From lat. 77° 55′ N., long. 53° 16′ E., 130 fathoms ; July 12th, 1897.

    4. *Idmonea tumida*, Smitt, × 12. From lat. 77° 55′ N., long. 53° 16′ E., 130 fathoms ; July 13th, 1897.

    5. Do. Natural size.

    6. *Alcyonidium gelatinosum*, L. Section × 85, showing the cuticula (*c*), the cuticula folded inwards at the oral aperture (*c f*). The layer of epithelial cells on the inside of the cuticula is shown as well as the endoderm lining the walls of the zoœcia. In the younger zoœcia divided off from the larger ones there are buds in various stages of growth. From North Wilczek Land.

    7. Do. Section × 125, showing the cuticula folded to the inside of the colony.

nut size

nut size

nut size

ARCTIC BRYOZOA.
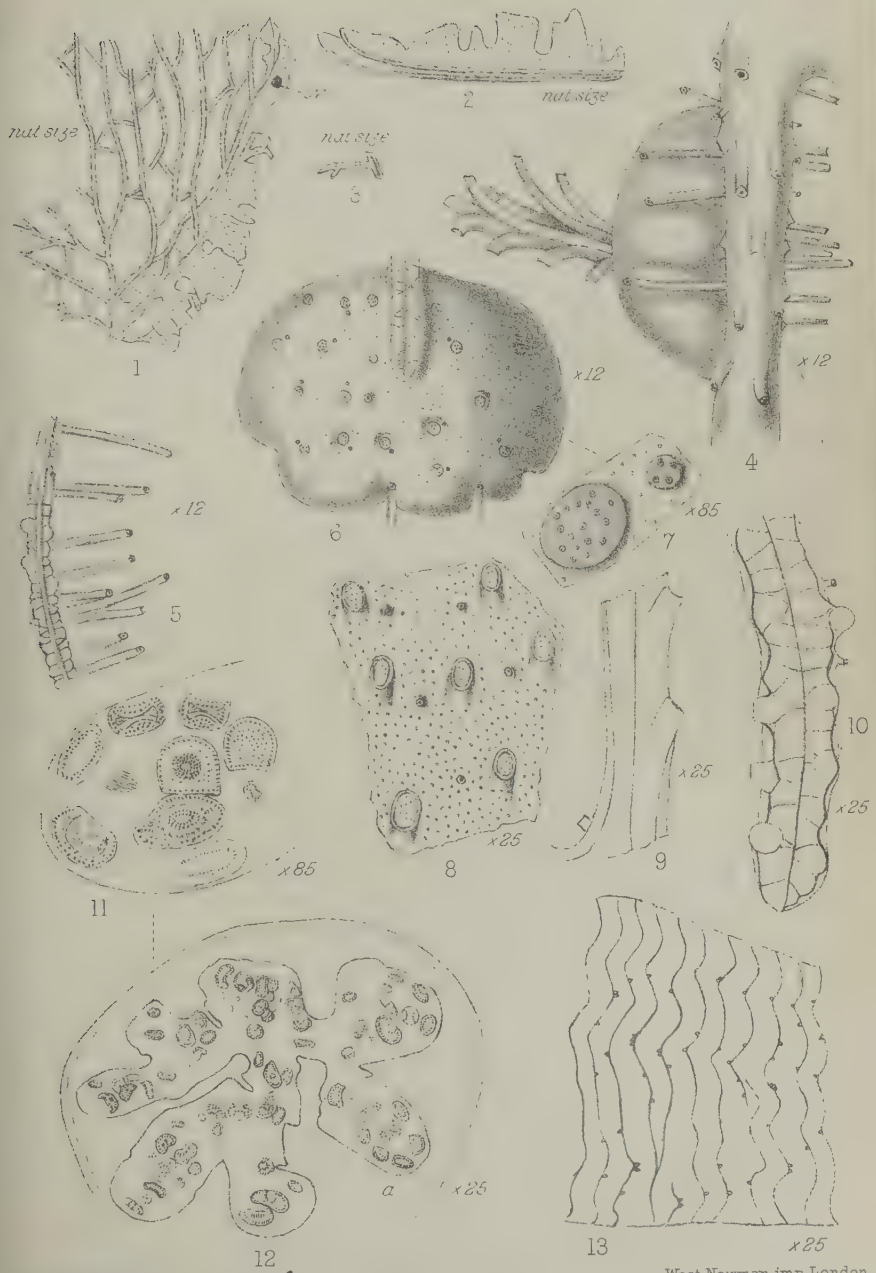
ARCTIC BRYOZOA.

A. W. Waters del.
A. T. Hollick lith.

West, Newman imp. London.

ARCTIC BRYOZOA.

On Coloration in Mammals and Birds.

By J. Lewis Bonhote, M.A., F.L.S.

[Read 5th May, 1904.]

Abstract.

The object of the paper has been to show, firstly, that the colour of a bird or mammal is primarily due to " activity of nutrition and function," which I have called " vigour," and that where conditions for a high state of vigour exist we shall find the majority of animals brightly coloured and *vice versa*.

" Vigour " is dependent on two causes :—

> (A) Climate, which contains two factors,
>> (1) Temperature,
>> (2) Food ;
> (B) The Rise and Fall of Sexual Activity.

For *Polar Regions*, where the two causes closely coincide, the changes are much more marked and violent.

In *Temperate Regions*, where the climate is sufficiently severe to affect the " vigour," but where, at the same time, there is a sufficiently long period of comparative plenty to prevent the sexual activity clashing with climate, the changes are less marked.

In *Tropical Regions* the first cause is practically removed, and any changes in colour are due to sexual causes, except in cases of temperate species which have spread into the south.

Now, the individual " vigour " of various species and groups will differ, and one animal may be able to maintain a full vigour under conditions which would be impossible to another. This will account for animals although Polar becoming brightly coloured, *e. g.* Musk Ox, Raven, Penguin, &c. It follows, therefore, that if they can maintain a full " vigour " in colder regions, they can either (i) maintain an equally full vigour in the tropics, or (ii) in hot climates their metabolism would become too active and they would die.

Consequently, a dark-coloured animal in Polar regions must either be confined to those regions or be cosmopolitan, *e. g.* Musk Ox, Raven.

By a similar process of reasoning, bright-coloured tropical animals will be found extending northwards, probably becoming

lighter, while white or light-coloured tropical animals will be confined to the tropics; *e. g.*, Tiger, and *Rhizomys sumatrensis*, the Bamboo Rat.

Seasonal change or migration is a necessity in Polar Regions, and birds, which migrate to the tropics, assume much more gaudy colours while in hot climates, becoming dull when the moult takes place in Arctic Regions, *e. g.* Knot (*Tringa*).

In Temperate Regions seasonal change will be a constant feature, but the changes will not be so marked, *e. g.* Squirrel, Deer; but when these animals reach torrid zones, the " seasonal change " will tend to persist for some time, gradually disappearing, or it may become a " breeding change," as in *Sciurus caniceps, Cervus Eldi*.

There is among mammals and birds a process known as " bleaching; " this, I attempt to show, is an *active* process, and not mere action of wind and weather.

I further show that *bleaching* always takes place along certain lines, starting and spreading in various degrees from certain centres; *e. g.*, lips, eyes, ears, crown of the head, occiput, shoulders, thighs, fore end of sternum, vent, tip of tail. To these centres or spots the name " pœcilomere " (spotted part) is given.

The second part of the paper is devoted to showing how these " pœcilomeres " exist as either white or deeply-coloured patches throughout the majority of species of Mammals and Birds : sometimes as large and conspicuous patches, *e. g.* hind-quarters of Rabbit, rump of Bullfinch ; and at other times only distinguished from the surrounding parts by difference of shade so slight as to be incapable of serving any warning, protective, or other similar purpose.

It is then pointed out that in some cases the " pœcilomeres " are only visible as transitory patches during the time an animal is undergoing a change of colour.

The head of the Stoat and of a young Shoveller drake are cited, amongst others, as examples of the change taking place along precisely similar lines, whence it is argued that as the outward effect is so slight and transitory, and as the process exists in two animals so widely separated, the fundamental cause must be a deep-seated physiological one.

I therefore claim to have shown that where conditions for

high vigour exist, the majority of the animals will be brightly coloured; and suggestions are made to account for the apparent exceptions to the rule, which suggestions, it is claimed, are borne out by the distribution of the dark polar and light tropical species.

I further claim to have shown that, shortly before the moult in many animals, the colour of the pelage fades, beginning along certain definite areas and from certain centres which I call "*pœcilomeres*," and that this bleaching is due to physiological causes.

Further, that "*pœcilomeres*" may be found throughout the mammalian and avian series, as patches differing either in their intensity or lack of colour from the surrounding portions, in many cases conspicuous and cited as examples of warning, protection, &c.; or, again, as marks so slight as to be unnoticeable unless carefully looked for; or, again, merely appearing as transitory patches during the growth of a new pelage or plumage.

Hence it is argued that these patches so universal, and in many cases so inconspicuous, must owe their inception to internal rather than external causes, and that we have here the basis of diversity of colour, *i. e.* coloration.

If these facts be accepted, both colour and coloration must be due to physiological causes.

The question of whether seasonal changes are produced by moult or by colour change has purposely been entirely omitted as belonging to a side issue.

Natural selection and protective coloration have also been left out, not because I do not believe in the great part they play, but because, if my suggestion be near the truth, they are only able to make use of those colours or modify those markings which in the first place are supplied by vigour.

On the Cranial Osteology of the Fishes of the Families
Mormyridæ, Notopteridæ and *Hyodontidæ.* By W. G.
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Mary's Hospital Medical School, London.

[Read 5th May, 1904.]

(PLATES **22–25.**)

THE Mormyroid fishes have always been an interesting family,
and have, on the whole, probably attracted more attention than
any similarly circumscribed and terminal group.   Owing to
their freshwater habit and geographical limitations generally,
their evolution has been constrained, and limited in the main to
certain parts of their organization, with the result that they
exhibit a most curious medley of primitive characters coupled
with highly specialized and even degenerate characters.   The
large size of the brain, the presence of an electric organ in the
tail, and the extraordinary shape of the snout in several of
the forms are indications of a high degree of specialization, yet
many of the other organs of the body show a retention of a
primitive condition.   There seems to be good reason to believe
that the family branched off early from the lower Malacopterygian
fishes, and became a terminal group.   Their nearest relatives
have generally been taken to be the Notopteridæ, with the
Hyodontidæ somewhat more remotely allied.   The study of
the skull in the three families Mormyridæ, Notopteridæ, and
Hyodontidæ forms the subject of the present communication.

Renewed interest in the Mormyridæ has recently been evoked
by the discovery of a great many new forms in the Congo,
described by Boulenger in the following three works:—Proc.
Zool. Soc. 1898, pp. 775–821 ; Ann. Mus. Congo, Zool. i.,
Bruxelles, 1898–1900 ; Les Poissons du Bassin du Congo, 1901,
Bruxelles, 8vo.   It is to him that I am indebted for the material
examined during the course of the present investigation, and to
him I beg to offer my sincere thanks.

MORMYRIDÆ.

The literature on the skull of Mormyroid fishes is not very
extensive.   *Gymnarchus* has been fully treated of by Erdl
(Abhandl. Bayer. Akad. Wiss., v. 1. 1847), and Hyrtl
(Denkschr. Akad. Wiss. Wien, xii. 1. 1856).   As regards the

other Mormyroids, Heusinger gives a couple of figures, rather crude, of the skull of *Mormyrus cyprinoides* in his paper on the auditory mechanism of certain fishes (Arch. f. Anat. u. Phys., 1826, pl. iv. figs. 8 & 9), but the standard work of reference is, of course, Marcusen's monograph (Mém. Acad. Sci. St. Pétersb., sér. 7, vii. 4. 1864). Marcusen did not include observations on *Gymnarchus* in this work.

MORMYROPS DELICIOSUS.

Cranium (Pl. 22. figs. 2 and 3).—The cranium is long, and tapers uniformly in an anterior direction almost to a point. The mesethmoid is low, and slightly bifid at the end. The vomer is small and edentulous, and is fused at its sides with the inner faces of the two palatine bones. Beneath the orbital region the parasphenoid has a slightly concave under surface, with vestiges of teeth close to the middle line. It is exceptionally broad just in front of the pro-otic bones, but narrows rapidly behind this, and terminates in a pair of narrow splinters of bone closely applied to the ventral surface of the basioccipital. The eye-muscle canal does not open posteriorly.

There is no opisthotic. The supraoccipital has a well-developed crest. The two parietals are fairly large, and meet in the median line by an extensive suture; the frontals are much elongated. Lying below the epiotic ridge and above the squamosal ridge is a large lateral foramen, occupied in nature by a thick-walled spherical vesicle, but opening in the dried skull directly into the cavum cranii. The foramen is bounded by the squamosal, epiotic, and exoccipital bones *.

The two alisphenoids are widely separated throughout, and are much drawn out in an antero-posterior direction. Lying in front of the alisphenoid, and touching it above the horizontally elongated optic foramen, is a bone which can only be identified with the orbitosphenoid. It is in extensive union with the parasphenoid below and the frontal above, and its transverse width is greater than its height. The cranial cavity extends into it, and the bone would be separated into a right and a left half were it not that the two parts are connected by a thin

* Boulenger's description of the lateral foramen of the Mormyroid skull (Les Poissons du Bassin du Congo, 1901, p. 49) as between the parietal and opisthotic is incorrect, for the opisthotic is wanting in all Mormyroids, and the parietal is in all cases separated from the foramen by the squamosal.

flooring which lies immediately above the parasphenoid.   There is no basisphenoid, and there are no separate prefrontals.

Temporal and Preopercular * *Series* (Pl. 22. fig. 1).—There are but two limbs to the post-temporal. The epiotic limb is the longer of the two; it is curved and slender. The other limb is broad and short, and extends forward towards the postero-ventral angle of the supratemporal.   There is no deep or opisthotic limb.   The supratemporal is a broad thin scale of bone, convex externally, which covers the supero-lateral parts of the squamosal and epiotic, and affords a lateral protection to the fibrous vesicle which lies in the lateral cranial foramen.

The interopercular is a comparatively thick bone behind, but it thins off in front into a long, thin ossified ligament, which lies in the groove that faces downward from the ventral edge of the preopercular and quadrate.   The vertical and horizontal limbs of the preopercular are not clearly distinguishable, since the bone has a uniform curve, with the concavity directed forwards and upwards.   A fair amount of the inner surface of the preopercular shows between the hyomandibular, interopercular, and opercular (fig. 4).

Circumorbital Series (fig. 1).—The nasal is fairly large, and has the form of a long semi-tubular bone which runs horizontally over the nasal sac, and takes a sharp curve downward at its anterior end, and terminates against the upper surface of the premaxilla.   The other bones of the series are four in number on each side; they are rather narrow, and in proportion to the size of the skull are feebly developed.

Maxillary Series (fig. 1).—The gape is premaxillary, and the two premaxillæ are fused in the median plane, the suture being obliterated.   Each premaxilla bears about thirteen teeth, slightly curved, and bluntly pointed.   The maxillæ have no teeth, and their anterior ends are separated by the mesethmoid. The anterior portion of each is narrow, the postero-ventral portion is expanded into a racquet-shaped plate.   There is no surmaxilla.

Mandibular Series (figs. 1 and 4).—The two dentary bones

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* The reasons for including the preopercular and interopercular bones in this series, and excluding them from the opercular and branchiostegal series, are given in a paper on the skull of the Elopidæ, &c., shortly to be published by the Zoological Society. For reasons given in the same paper it is considered expedient to regard the post-temporal as a constituent of the skull.

are fused at the symphysis, and the suture is obliterated. Each bears thirteen or fourteen teeth, stout, bluntly pointed and slightly curved. The sesamoid articular is distinct, and is set rather higher up the articular than is usually the case. There is no separate angular bone.

Hyopalatine Series (figs. 1 and 4).—The opercular head of the hyomandibular is extremely short. The hyomandibular, strictly speaking, articulates with the cranium by two heads, the posterior about four times as broad (antero-posteriorly) as the anterior; but in the dried skull, in which the synovial cartilage has shrunk up, the distinction is no longer visible, the upper edge is nearly straight, and does not stand at a higher level than that of the metapterygoid, which is in fibrous union with the lateral edge of the parasphenoid. Indeed, the hyopalatine arch is united with the cranium by the whole of its upper edge, and is separable from it with difficulty. In relation, doubtless, with the length of the head, the axis of the hyomandibular slopes well forward, the metapterygoid is about twice as long as high, and the quadrate is drawn out to a considerable length in an antero-posterior direction. There is no separate symplectic, and no separate entopterygoid; the palatine is small and fused on to the side of the vomer. There are no teeth on the palatine or pterygoid bones.

Opercular Series (figs. 1 and 4).—The opercular bone is nearly rhombic in shape; the subopercular is small and triangular, and concealed in an external view by the lower part of the opercular bone.

The branchiostegal rays are seven in number on each side; the first four are slender, curved rods, but the fifth and sixth are slightly expanded at their posterior ends. The first two are attached to the hinder part of the ceratohyal, and the next three to the lower edge of the epihyal, although, on account of a process of the ceratohyal which projects backwards on the outer face of the epihyal, they appear to arise from the ceratohyal when examined in an external view. The last two, which are shorter than the fifth, are free from the epihyal, but lie close alongside the ventral edge of the opercular bone.

Hyobranchial Series.—The interhyal is cartilaginous. The anterior part of the hyobranchial skeleton is very aberrant. There is no separate hypohyal; but firmly fixed in between the urohyal below and the dentigerous membrane-bone above is a

cartilage-bone of considerable size which may be taken to include the glossohyal (endosteal part) and the first basibranchial. The ceratohyal fits on to the side of this compound bone. The urohyal is a large vertically disposed plate of bone, having a thin posterior edge. It is immovably fixed, and is united not only with the bone just mentioned, but also with the under surface of the anterior two-thirds of the second basibranchial. The usual paired ligament so characteristic of the urohyal is not recognizable. The dentigerous membrane-bone is narrow, bears some forty, more or less vestigial teeth, and extends back over nearly the whole of the second basibranchial. The third basibranchial is a small flat plate of bone.

The first hypobranchials are not rods of bone projecting freely backward and outward from the junction of the first and second basibranchials, and setting the anterior ends of the first ceratobranchials at some distance from the mesial structures, but they are quite short bones, closely applied to the sides of the second basibranchial in such a way that the antero-internal point of the first ceratobranchial nearly touches the side of the second basibranchial. In a somewhat similar way the anterior ends of the second ceratobranchials come close to the mesial series of bones; but in this case the hypobranchials project downward from the sides of the posterior end of the second basibranchial, and are fused with a pair of tendon-bones similar to those of *Notopterus* (see page 206). (It must be borne in mind, however, that the first, second, and third hypobranchials of *Notopterus* are quite normal, and that the paired tendon-bones are readily separable from the antero-inferior ends of the second hypobranchials and the postero-inferior surface of the second basibranchial.) The reasons for not considering the whole bone as the equivalent of the tendon-bone of *Notopterus*, and regarding the second hypobranchial as wanting, is that the upper part of the bone has the appearance of a cartilage-bone, which is not the case in *Notopterus*; that the third hypobranchials are, though small, downwardly directed; and that it strikes one as improbable that the second hypobranchials should disappear absolutely while the first and third remain.

The first pharyngobranchial is present, and has the form of a small triangular plate of bone, horizontally placed, and in contact with the antero-internal edge of the first epibranchial and the anterior edge of the second pharyngobranchial. There

is no spicular bone. The third pharyngobranchial is not longer than the second, and overlaps it only to a very slight extent. The four epibranchials are approximately equal in length, and the fourth is not expanded.

PETROCEPHALUS BANE.

Cranium (Pl. **23.** figs. 6, 7, and 8).—Probably the most remarkable feature about the cranium of *Petrocephalus* is the unusual height of the mesethmoid region. The mesethmoid lies below the frontal bones, the anterior wings of which extend to the extreme front of the cranium, and its lower part is set well in advance of the vomer. The latter bone is small and edentulous, and is fused at its sides with the mesial faces of the two palatine bones. The parasphenoid is of considerable vertical height in its anterior part; it carries on its ventral surface a lanceolate patch of some thirty teeth, which are single-pointed, and thus differ from those of the jaws. The parasphenoid extends as far backward as the middle of the under surface of the basioccipital; there is no posterior opening to the eye-muscle canal.

The articular groove for the reception of the hyomandibular is set low down the side of the cranium, and the pro-otic is four-sided and faces downward, instead of downward and outward. Between the epiotic ridge and the squamosal ridge is a large aperture leading into the *cavum cranii* in the dried skull, but in nature lodging a nearly spherical thick-walled vesicle. The aperture is bounded by the exoccipital, epiotic and squamosal. There is no opisthotic. The supraoccipital has a strongly developed median crest; the two parietals meet in the middle line, and at their junction form a low crest, continuous with that of the supraoccipital.

The frontal bones are rather small, and each has a slender bar of bone arching obliquely over it. The prefrontals are small but distinct; they do not touch one another in the median plane. A basisphenoid is present, and is united above with the orbitosphenoid and alisphenoid, and below with the parasphenoid. The orbitosphenoid is larger than the alisphenoid, and extends from the frontal above to the parasphenoid below.

Temporal and Preopercular Series (figs. 5 and 9).—The post-temporal resembles that of *Mormyrops*. The supratemporal

is remarkably large, and has the form of a thin convex plate of bone covering the dorsal part of the squamosal and the lateral parts of the parietal and epiotic bones. It forms a protective covering for the lateral cranial foramen. The preopercular is narrow, and its forwardly directed ventral limb is short; the interopercular is small and is concealed in an external view by the preopercular.

Circumorbital Series (fig. 5).—The nasal is a large curved bone. On its dorsal surface is a broad groove which narrows along its anterior surface, and terminates in a point at the ventral end of the bone. The circumorbital bones proper are six in number on each side. The preorbital is of moderate size, the two suborbitals are comparatively large, and the three postorbitals are narrow incomplete tubes.

Maxillary Series (fig. 5).—The gape is premaxillary; the two premaxillæ are fused in the median plane, and the suture is obliterated. They are comparatively short and stout, and each bears about eight teeth, slender, and bifid at the tip. The maxillæ are curved, toothless bones of fair size, which touch one another in the median plane immediately in front of the vomer and behind the mesethmoid. Each has a dorsal process which projects horizontally backward, and is lodged beneath the first suborbital bone. There is no surmaxilla.

Mandibular Series (figs. 5 and 9).—The two dentaries are fused in the median plane, but the suture remains visible. Each carries about eleven teeth, slender, and bifid at the tip. There is no clear distinction between the ectosteal, endosteal, and sesamoid constituents of the articular; neither is the angular a distinct bone.

Hyopalatine Series (fig. 9).—The union between the upper edge of the hyopalatine arch and the cranium is of a very intimate character; in fact, the palatine has its mesial face so closely united with the vomer, parasphenoid, and prefrontal that to separate it without breaking its substance is impossible. The palatine is a rectangular plate of spongy bone standing vertically against the side of the front of the parasphenoid; the usual articular heads cannot be recognized. There is no separate entopterygoid, and the ectopterygoid, like the palatine, is edentulous. The lower edge of the ectopterygoid has a uniform curve; there is no sharp angulation. The hyomandibular is broad, and articulates with the cranium by what

at first appears to be one long continuous head, although strictly the anterior extremity, immediately over the foramen, is a small separate head. The axis of the hyomandibular is inclined in a forward direction, and, in the absence of a distinct symplectic, is attached to the postero-superior edge of the quadrate.

Opercular Series (figs. 5 and 9).—The subopercular is small, and is concealed in a lateral view by the lower part of the opercular bone. The branchiostegal rays are eight in number on each side, and, with the exception of the last but one, all are slender and of uniform width. The first four are attached to the outer face of the ceratohyal, the next two to the epihyal, while the last two are free from the epihyal, but lie close under the ventral edge of the opercular bone.

Hyobranchial Series.—The first, second, and third basibranchials are ossified, the first being the largest and the third the smallest. There is no glossohyal. There is a dentigerous membrane-bone, nearly circular in outline, overlying the middle part of the first basibranchial, and immediately behind it is another dentigerous membrane-bone, longer and narrower than the former, and covering the hinder part of the first basibranchial and the anterior half of the second. The teeth upon these bones have single points like those of the parasphenoid. The third basibranchial has the form of a rod curved into the fourth part of a circle, so that, while its anterior part is horizontal, its posterior part projects down vertically between the downwardly directed third hypobranchials. The relations of the hypobranchials and the pair of tendon-bones are exactly as in *Mormyrops*.

The urohyal is short, and consists mainly of a vertical sheet of bone less than twice as long as high; it articulates with the ventro-internal surfaces of the anterior ends of the ceratohyals, and also by an extensive articular surface with the under parts of the posterior three-fourths of the first basibranchial and the anterior one-fourth of the second basibranchial.

The ceratohyals are short and wide. There is but a single hypohyal to each, the upper of the two normally present in Teleosteans. It is small in size, and is wedged closely beneath the anterior of the two dentigerous bones.

There is no first pharyngobranchial, nor a spicular bone; the second pharyngobranchial is a horizontally disposed plate of

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bone, roughly square in outline; the third is a slightly curved, forwardly directed rod, which is attached to the posterior end of the second pharyngobranchial, and not, as is more usual, to the mesial edge of its anterior end.

Other MORMYRIDÆ.

The skulls of *Mormyrops* and *Petrocephalus* just described were specially prepared for the purposes of this investigation from alcohol-preserved material kindly furnished by Mr. G. A. Boulenger; but for comparison with them I have been glad to avail myself of ready-prepared skulls of five other genera of Mormyroid fishes from the Osteological Collection of the British Museum.

Two species of *Mormyrus* were examined, *Mormyrus caschive* (a complete specimen, Brit. Mus. No. 1441, Nile; and a large fragmentary skeleton, also from the Nile), and *Mormyrus hasselquisti* (Brit. Mus. No. 879, Fashoda). The general aspect of the skull is the same as that of *Mormyrops*, but parasphenoidal teeth are well developed, and there are distinct prefrontal bones; the orbitosphenoid has the appearance of being completely divided into a right and a left part, but without cutting the skull I am unable to make a definite statement on this point. The dentition of the premaxilla and dentary is more feeble *, and the teeth are bifid at the tip, like those of *Petrocephalus*. The maxilla is of remarkable shape (Pl. 23. fig. 10) in consequence of the exceptional size of the horizontal, posteriorly directed process *a*. The mandibular rami are much longer and narrower than in *Mormyrops* and *Petrocephalus*.

The relations of the hyopalatine arch are similar to those of *Mormyrops*, but in *Mormyrus caschive* there arises from the postero-dorsal part of the pterygoid (probably the ectopterygoid, but as there is no recognizable entopterygoid it is difficult to say for certain) a process of bone which is united by a jagged suture with the antero-ventral part of the orbitosphenoid. In *Mormyrus hasselquisti* there is but the feeblest suggestion of such a connection.

The horizontal limb of the preopercular is approximately as long as the upright limb, the two being set at an angle of about

* Boulenger (Proc. Zool. Soc. 1898, p. 780) employs this as a distinctive character, *Mormyrops* and *Petrocephalus* having 12 or more teeth in each jaw (upper and lower), whereas all the other genera (except *Gymnarchus*) have not more than 10 teeth in each jaw.

105 degrees ; and about one-half of the interopercular is visible
in an external view of the skull below the lower edge of the
preopercular.   The ceratohyal is relatively shorter and stouter
than in *Mormyrops*, and the dentigerous membrane-bone longer
and more strongly toothed ; but the essential features of the
hyobranchial skeleton are the same in both.

Prepared skulls of *Marcusenius isidori* (Brit. Mus. No. 796,
Nile), and *Gnathostomus cyprinoides* (Brit. Mus. No. 1210, Nile)
were also examined, but no new features of interest were
discovered.

Hyperopisus bebe (Brit. Mus. *Mormyrus dorsalis*, 62.1.17.76,
Khartoum) is remarkable for the great development of the para-
sphenoid and hyobranchial dentition.   The teeth are flat-topped,
and are closely set in the form of a pavement.   Both upper and
lower patches of teeth are of considerable breadth, and form a
very efficcient crushing apparatus.

Two skulls of *Gymnarchus niloticus* * were examined, one
about 10 inches long, and the other (Brit. Mus. 91.4.2.26, Lagos)
about $4\frac{1}{2}$ inches.   The skull of *Gymnarchus* has been so well
figured by Erdl (Abhandl. Bayer. Akad. Wiss. v. 1. 1847, pl. 5)
and Hyrtl (Denkschr. Akad. Wiss. Wien, xii. 1. 1856, pls. 1
& 2), that a bare description will here suffice.   Unfortunately
the figures of Hyrtl are not lettered, but the numbers attached
to the parts in Erdl's figure will serve in the subjoined remarks
for the recognition of bones, although the names which he
gives to the bones are now obsolete.   Marcusen did not in-
clude observations on *Gymnarchus* in his monograph on the
Mormyridæ.

The cranium is long, and the mesethmoid low.   There is no
supraoccipital crest ; the parietals meet ; there is no opisthotic.
The lateral cranial foramen of *Gymnarchus* should rather be
described as a hemispherical depression, from the depths of
which three apertures lead into the cranial cavity. Its margin is
formed by the exoccipital, epiotic, and squamosal as in other

* Although the skull, and particularly the branchial skeleton, of *Gymnarchus*
possesses some very remarkable features, I am disposed to follow Günther
(Study of Fishes, 1880, p. 626) and Boulenger (" Revision of the Mormyridæ,"
Proc. Zool. Soc. 1898) in retaining the genus in the family Mormyridæ, rather
than to accept the earlier view of Günther (Brit. Mus. Cat. Fishes, vi. 1866,
p. 225), and of Cope (Trans. Amer. Phil. Soc., n. s. xiv. 1871, p. 454), that it
should constitute a separate family, the Gymnarchidæ.

Mormyroids, and it is covered by a thin scale-like supratemporal (No. 12 of Erdl's figure). The postfrontal is small, and is wedged in between the front part of the squamosal and the upper edge (there is no proper articular facet) of the hyomandibular.

The interorbital septum is thin and bony. At the back of the orbit is the alisphenoid (No. 17 of Erdl), in front of this the orbitosphenoid (No. 18), and below and partially between them is a fair-sized basisphenoid (No. 16a). In front of the orbitosphenoid is a curious bone (No. 6) which forms the most anterior part of the interorbital septum, and is united laterally by jagged sutures with the upper edge of the ectopterygoid and the postero-superior edge of the palatine. There seems to be no alternative but to regard this bone as the two prefrontals fused in the median plane. The cranial cavity is continued into the upper part of this bone, and divides anteriorly into two passages transmitting the stalks of the right and left olfactory lobes of the brain.

The connection between the hyopalatine arch and the cranium is of a far more intimate and rigid nature than in any other of the Mormyridæ examined : there can be no possibility of movement of the hyopalatine arch. The axis of the hyomandibular is drawn forward until it is nearly horizontal. The parasphenoid is short, broad, and nearly flat (No. 16 in Erdl's lower figures), and its anterior part is underlaid by the broad thin end of the bone No. 5, which I take to include the vomer, the endosteal mesethmoid †, the two palatines, and the two entopterygoids, fused together. This bone has no teeth : neither has the parasphenoid. The metapterygoid (No. 22) lies nearly horizontal in the floor of the orbit, above the lateral expansion of the parasphenoid. There is no recognizable symplectic.

The posterior extremity of the epiotic ridge (No. 10) is in intimate ligamentous relation with the stout upper end of the supraclavicle (No. 36). The post-temporal (No. 36*) is quite a small bone, of which none of the three usual limbs (epiotic, opisthotic, and supratemporal) can be recognized. It lies immediately external to the junction of the supraclavicle with the epiotic.

† The ectosteal mesethmoid (No. 7) is readily separable from this. The closer union of the endosteal mesethmoid with the vomer than with the ectosteal mesethmoid is paralleled in *Megalops*.

The nasal (No. 3) is narrow and hook-shaped, and semitubular. The suborbital series is constituted by a chain of 9 to 12 bones, which run nearly in a straight line from the back of the premaxilla to the front of the squamosal. The first of these is an oval plate of bone, the size and shape of which are better represented in Hyrtl's figure than in Erdl's; but the others are merely tubes of bone conveying the cutaneous sensory organ.

The two premaxillæ are rigidly united by an interlocking suture. Each has about seven teeth. The maxillæ (No. 2) are curved rods of bone, without teeth; they are widely separated one from the other, they are attached by fibrous tissue to the posterior ends of the premaxillæ, and are not connected with the cranium in any way.

The two dentaries are not fused at the symphysis; each bears 13 or 14 teeth (see fig. 11), those at the front square-ended[*], like the premaxillary teeth, those behind bluntly pointed. The teeth are minutely serrated along the edges. The articular facet for the reception of the head of the quadrate is formed by two bones. The upper one (No. 26 of Erdl's lower figures) is obviously the endosteal articular, while the bone (No. 25) that forms the other half of the facet represents the angular bone fused with the ectosteal articular. There is a well-developed sesamoid articular (No. 27), suturally united with the antero-superior edge of the endosteal articular (see fig. 11).

The subopercular (No. 30) is relatively small, but it is not entirely concealed by the opercular bone; it agrees with that of other Mormyroids, however, in terminating in a point posteriorly. The interopercular is large and long, and is concealed by the preopercular. The horizontal limb of the preopercular is nearly twice as long as the upright limb: it is represented as too short by Erdl (No. 28, lower figures).

Only four branchiostegal rays are present on each side. Of these, the first is attached to the ceratohyal, the next two to the epihyal, and the last, which is the shortest, lies along the ventral edge of the interopercular, to which its anterior portion is attached by fibrous tissue. Hyrtl (*l. c.* p. 16) states that his specimen had seven branchiostegal rays on the right side and six on the left; but Erdl (*l. c.* p. 229), Duvernoy (Ann. Sci. Nat.

[*] The curious chisel-edge of these teeth is not the effect of wear, for the reserve teeth, yet uncut, present the same feature.

(3) xx. 1853, p. 160), and Boulenger (Poissons du Bassin du Congo, 1901, p. 50, footnote) all record the number as four.

The epihyal is relatively longer and larger than in other Mormyroids; there are no hypohyals. The urohyal is fused with that bone which in *Mormyrops* (p. 191) was taken to represent the first basibranchial and the endosteal glossohyal combined. This compound bone is the No. 33 of Erdl (bottom of plate, left-hand side); its front part is marked *a*, and its hinder part *b* in Hyrtl's figure 2 of plate 1. The great pair of tendon-bones (*g* of Hyrtl's figure) show less evidence of containing a hypobranchial element than in other Mormyroids; they are strongly curved, and extend horizontally outward and then backward. Their antero-internal extremities are closely bound by ligament in the median plane, but partially between them, and projecting a little in front of them, is a small rod of bone, the reduced second basibranchial. In Hyrtl's figure the letter *h*, although not on the bone, but to the right side of it, is evidently intended to apply to it, for he describes *h* as " der mediane Knochenkern in der Symphyse der mit *g* bezeichnete Knochen." There is no third basibranchial.

Touching one another above the glossohyal is a pair of small bones, apparently representing the dentigerous membrane-bone, although they are toothless. They are not shown in Hyrtl's figure, but one of them is shown in Erdl's lower figures; it is marked No. 35, and is called (p. 228) " kleines Zungenbeinhorn, ein länglicher, ziemlich cylindrischer Knochen. Beide kleine Hörner stossen mit ihrem vorderen Theile an einander, nach hinten divergiren sie." In a footnote on the succeeding page, Erdl compares these small bones with the unpaired dentigerous membrane-bone that lies over the endosteal glossohyal of *Mormyrus*.

The first hypobranchial * is a small rod-like bone, lying across the anterior extremity of the first ceratobranchial; it fails by a good deal to reach the median line. The second hypobranchial may be fused with the paired tendon-bone, but the third hypobranchial is wanting. The reduction of the hypobranchials, however, does not bring the anterior ends of the ceratobranchials closer to the median line. The ceratobranchials of the right and left sides remain, in fact, widely separated.

The four epibranchials are short and subequal. There is no

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* This and the pharyngobranchials are not shown in Hyrtl's figure.

first pharyngobranchial; the second and third are quite short, the second being triangular and the third square in general outline. The pharyngobranchials of the right and left sides are rather widely separated, and there intervenes a considerable expanse of pharyngeal mucous membrane unsupported by skeletal parts.

Distinctive Features of the Mormyroid Skull.

The following features, present in the seven genera *Mormyrops*, *Petrocephalus*, *Marcusenius*, *Gnathostomus*, *Hyperopisus*, *Mormyrus*, and *Gymnarchus*, will doubtless prove to be common throughout the family Mormyridæ.

The parietal bones meet in a median suture, and are not separated by the supraoccipital; an orbitosphenoid is present, but no opisthotic; there is a large lateral cranial foramen, bounded by the squamosal, epiotic, and exoccipital, and loosely overlaid by a thin, scale-like supratemporal *; there is no posterior opening to the eye-muscle canal. There are no teeth on the maxillary, vomerine, palatine, and pterygoid bones. There is a very extensive attachment of the whole of the upper edge of the hyopalatine arch with the cranium; there is no separate symplectic, and no separate entopterygoid. The palatine is fused with the side of the vomer; the right and left premaxillæ are fused together, although the suture may remain visible, as in *Gymnarchus*; there is no surmaxilla. The subopercular terminates in a point posteriorly, and, except in *Gymnarchus*, is entirely concealed by the opercular. The hypobranchials are greatly reduced, and a pair of large tendon-bones project downward and outward (horizontally outward and backward in *Gymnarchus*) from the hypobranchial region. There is no separate glossohyal; it is either wanting (*Petrocephalus*), or is fused with the first basibranchial. The urohyal is without the usual paired ligament in front; it is rigidly fixed, or even fused (*Gymnarchus*), beneath the anterior part of the copular skeleton.

* The extensive overlapping of the parietal by the supratemporal, given by Boulenger (Ann. Mag. Nat. Hist. [7] xiii. 1904, p. 164) as a family character, is fallacious. In the Mormyridæ the supratemporal covers very little of the parietal bone; in some species, e. g. *Mormyrops deliciosus* and *Gymnarchus niloticus*, it does not even reach the parietal.

Notopteridæ.

Notopterus kapirat.

The hinder part of the cranium of *Notopterus* has been described and figured by Bridge in his paper on the Air-bladder and Auditory Organ of *Notopterus borneensis* (Journ. Linn. Soc., Zool. xxvii. 1900).

Cranium (Pl. 24. figs. 13, 14, and 15).—The appearance of the cranium is remarkable on account of the five sharp ridges, two paired and one median, which run lengthwise along it. The median one is formed by the frontals and supraoccipital, the upper lateral by the frontal, parietal, and epiotic, and the lower lateral by the frontal and squamosal. Between the hind ends of the two lateral ridges is a large foramen—the " lateral cranial foramen "—leading, in the dried skull, directly into the cranial cavity. It is bounded in front by the squamosal, behind by the exoccipital, and above by the squamosal and epiotic *.

The supraoccipital crest is of considerable size, and in front of it the two parietals meet in the middle line of the head. The anterior half of each is superficial, and is covered by skin only, the posterior half is situated at a somewhat deeper level, and is covered by muscle as well as skin. The squamosal extends remarkably far forward, running completely over the postfrontal, and resting its anterior end above the alisphenoid. The epiotic is of small vertical extent. At the back of the cranium, between the supraoccipital crest and the epiotic prominence, is a depression occupied by trunk muscles, and into the constitution of which the exoccipital enters largely. The opisthotic is of moderate size ; it is set rather low down, and lies beneath the squamosal and exoccipital, and touches the pro-otic in front.

The postfrontal is small and does not enter into the hyomandibular-cranial articulation. The articular surface for the head of the hyomandibular is formed by the pro-otic and squamosal in front, and by the exoccipital behind, a small portion of the latter bone presenting itself between the squamosal above and the opisthotic below and behind. The exoccipitals just succeed in meeting above the foramen magnum, but do not form any extensive suture. The base of the skull is

* It is not surrounded by the squamosal (pterotic) as stated by Cope (Tr. Amer. Phil. Soc., n. s. xiv. 1871, p. 454) ; neither is it bounded by the postfrontal and squamosal as Boulenger states (Poissons du Bassin du Congo, 1901, p. 115, and Ann. & Mag. Nat. Hist. [7] xiii. 1904, p. 164).

inflated, the bulla being formed by the pro-otic and basioccipital at the side, and by the posterior end of the parasphenoid below. Behind the bony swelling is a ventro-lateral vacuity bounded above by the opisthotic and pro-otic, and internally by the basioccipital. This vacuity lodges the inner and upper portion of a rather large air-vesicle, the outer and lower walls of which are fibrous, and are consequently wanting in a macerated skull. The anatomy of this diverticulum of the swim-bladder has been minutely described by Bridge (*l. c.*), who terms it the " auditory cæcum."

The basisphenoid is of fair size. It is nearly horizontally disposed, has no descending limb, and is slightly convex on its lower surface. At its sides it touches both alisphenoid and pro-otic. The foramen between the alisphenoid and the pro-otic is situated unusually high up the back of the orbit. The two alisphenoids meet one another behind the orbitosphenoid, which is rather exceptional; and the olfactory lobes run the whole of their course within the orbitosphenoid and prefrontal bones.

The parasphenoid is broadened out into a rhombus in its hinder portion, and its posterior extremity lies beneath the middle of the length of the basioccipital, or even a little in advance of this. The eye-muscle canal is short and blind. The parasphenoid bears an elongated patch of teeth, and its lateral wings extend a fair distance up the front of the pro-otic bones. The vomer bears a small patch of teeth near its anterior end. It extends rather more anteriorly than the mesethmoid, which fits closely on the front of the prefrontals, the ethmoid region of the cranium being short. There is an extensive union of the right and left prefrontals in the median plane of the head.

Temporal and Preopercular Series (fig. 12). — The post-temporal has the form of a tube, elliptical in section, and opening obliquely at both ends on its cutaneous aspect. The anterior end is attached by fibrous tissue to the back of the exoccipital and to the upper part of the opisthotic. The lower edge of this bone must thus be regarded as the opisthotic limb. The epiotic limb is wanting. In *Notopterus afer* (Brit. Mus. 95.7.18.49, Old Calabar) there is a separate opisthotic limb, a long, slender, delicate rod.

The supratemporal is an elliptical scale of bone, which does not carry the sensory tube, but lies at a slightly higher level.

The branch of the sensory tube which forms the parietal commissure arises anteriorly to the supratemporal. The supratemporal lies on the external, *i. e.*, lateral side of the epiotic, and touches the posterior part of the parietal. On account of its small size it fails to act as a cover to the large lateral foramen of the cranium.

There is a more than usually intimate connection between the preopercular and postero-superior extremity of the quadrate. On the lower part of the preopercular are two sharp serrated ridges, which form a posterior continuation of the two serrated ridges of the mandible; and in the middle of the outer face of the preopercular is a circular depression with an incomplete posterior border, by which the sensory canal comes to the surface of the head. In the undissected head this hole is seen to be closed by a delicate, scaleless membrane, similar to that which covers the posterior end of the post-temporal. The upper end of the preopercular fits closely into the lateral notch that occurs near the posterior end of the squamosal (fig. 13). The interopercular lies some considerable distance up the inner face of the preopercular.

Circumorbital Series (fig. 12).—The bones of this series are seven in number. The nasal is large, and forms the anterior as well as the dorsal border of the nasal aperture. The two nasal bones touch one another above the mesethmoid, and form a sharp median crest. The first two of the three suborbital bones are moderately large, and have a serrated lower margin. The anterior of the three gives off from its front end a process which passes inward and upward, and enters into a definite articulation with the under side of the prefrontal. A somewhat similar process passes inwards from the posterior end of the second suborbital, accompanied by a similar process from the anterior end of the third. These processes are attached by ligament to the outer surface of the ectopterygoid and entopterygoid. The uppermost postorbital has the form of a tube, through which passes the sensory tube on its way from the dorsal surface of the squamosal and frontal (fig. 13, *sc.*) to the groove in the orbital edge of the postorbital and suborbital bones.

Maxillary Series (fig. 12).—Both maxilla and premaxilla bear moderately long, pointed teeth on the external edge of their lower border, and smaller teeth on the buccal side of these. The anterior end of the maxilla lies above the premaxilla, and

articulates with the side of the vomer. There is no sur-maxilla.

Mandibular Series (figs. 12 and 16).—The angular is distinct, and of large size. The dentary bears a row of pointed teeth on its outer edge, and crowded small teeth on its supero-internal surface. There are two lines of serrations in each ramus of the mandible, one along the ventral edge of the dentary and angular, and another on the outer face of the dentary. A sesamoid articular of moderate size is present; the endosteal articular is not distinct from the ectosteal articular.

Hyopalatine Series (fig. 16).—The hyomandibular articulates with the cranium by a single broad head. The symplectic is much expanded, and unites suturally with the lingual faces of the preopercular, the metapterygoid, and the quadrate. Teeth are borne by the palatine, ectopterygoid, and entopterygoid. The palatine articulates with the ethmoid region by a single head. The ectopterygoid is fused with the palatine, and its lower edge is nearly straight, and has no angulation in the middle of its length.

Opercular Series (fig. 12).—The opercular bone is comparatively small in size, and is marked by shallow radiating ridges. The size of the gill-cover is considerably larger than that of the opercular bone would lead one to suppose; there is a broad posterior margin not supported by bone. There is no subopercular bone.

The branchiostegal rays are eight in number; they are all curved rods, and the posterior ones show very little tendency towards flattening. The first two lie free in the branchiostegal membrane, the third is attached to the edge of the ceratohyal, and the remaining five to the outer face of this bone, the last, which is the largest, overlapping much more of the bone than the others. None are attached to the epihyal.

Hyobranchial Series (fig. 17).—There are twelve long and rather stout gill-rakers on the first branchial arch, but those on the other branchial arches are short and blunt. They are all readily removable from the underlying bone. The interhyal is cartilaginous, or is very slightly ossified.

The epihyal is small as compared with the ceratohyal, and the hypohyal is small, and single on each side. It is probably the lower of the two hypohyals which is wanting, or unossified, since the anterior ligaments of the urohyal, usually connected

with the lower hypohyals, are attached in *Notopterus* to cartilage below the level of the single hypohyal bones. The glossohyal is large and well ossified on the surface, although cartilage persists in the interior, there being no endosteal glossohyal; it bears large, strongly curved teeth around its edge. The first basibranchial is unossified. Above the first, second, and third basibranchials is a membrane-bone which bears small crowded teeth over nearly the whole of its upper surface. Small teeth also occur on the fifth ceratobranchials. The first pharyngobranchial is small and cartilaginous, and there is no spicular bone.

The urohyal is rather short and broad, and a pair of ossified tendons, similar in structure and function to the urohyal, and together nearly equalling the urohyal in size, project downward, outward, and backward from the lower surface of the posterior end of the second basibranchial.

HYODONTIDÆ.

HYODON ALOSOIDES.

Cranium (Pl. 25. figs. 19, 20, and 21).—The characteristic appearance of the cranium is due to the low position of the anterior three-fourths of the parasphenoid. This part is curved and strongly toothed, and makes a distinct angle with the posterior part. The parasphenoid underlies but a small portion of the basioccipital, and the eye-muscle canal opens at its posterior end by an oval foramen. The vomer is small and edentulous.

The ethmoid region is short. The frontals also are rather short, and the parietals are consequently more anteriorly placed than usual. The two parietals meet in the middle line, but only for a short distance. The supraoccipital separates the hinder parts of the parietals, and possesses a crest which is T-shaped in transverse section. Each of the exoccipitals has a vertical wing situated at the side of the foramen magnum. The opisthotic is rather large, and forms the greater part of what at first glance appears to be the squamosal spine. The opisthotic forms part of the articular cavity for the posterior head of the hyomandibular, which fact is exceptional.

A side view of the cranium shows an oval tract of cartilage bounded by the epiotic, parietal, and squamosal. This is not to be confounded with the lateral foramen of *Notopterus* and the

Mormyridæ, bounded by the squamosal, epiotic, and exoccipital, although there is probably some degree of morphological relationship existing between the two. It finds its nearer equivalent in the lateral depression (pre-epiotic fossa), which in *Osmerus*, *Clupea*, &c. is situated immediately in front of the vertical posterior edge of the epiotic bone.

At the side of the base of the cranium, and below the level of the squamoso-opisthotic ridge, is a great vesicle of the swim-bladder. Its outer wall is composed of fibrous tissue, which is attached to the cranium along the line marked with dots in fig. 20. Its inner wall is formed by the exoccipital and basi-occipital, and its anterior wall by a vertical lamina of the pro-otic. Between the exoccipital, basioccipital, and pro-otic is a fairly large auditory fenestra *, opening into the perilymphatic cavity, and traversed vertically by the pro-otic lamina just mentioned. The foramen for the vagus, situated dorso-posteriorly to the vesicle of the swim-bladder, is of large size.

On separating the cranium from the vertebral column, the basioccipital and the exoccipitals part readily from the half-centrum, and are left exhibiting a rough surface with the usual triradiate suture. The vertebral body † is not shorter antero-posteriorly than the centra that follow, and it is provided with a complete neural arch, the paired spinous processes of which are but little smaller than those of the succeeding vertebræ. *Hyodon* must thus be regarded as one of the instances in which the tendency for the appropriation of the first centrum by the basicranial axis is of the slightest character.

The basisphenoid is situated farther forward than usual, and has no vertically descending process. It extends so far forward beneath the alisphenoids as to touch the orbitosphenoid, and it forms the superior edge of the optic foramen. The orbito-sphenoid is U-shaped in section, and, at least in the dried skull, the cranial cavity continues through it to the ethmoid region. The orbitosphenoid nearly touches the prefrontals, but is separated from them by a narrow tract of cartilage. The interorbital septum below the orbitosphenoid and basisphenoid is membranous.

* The auditory fenestra is a Clupeoid feature, and its occurrence in *Hyodon* is of some interest.

† It is not shown in figures 19, 20, and 21.

Temporal and Preopercular Series (figs. 18 and 22).—The post-temporal consists practically of its two limbs, there being no body to speak of. The upper limb is long, and its extremity is loosely attached to the upper surface of the epiotic; the lower is short, and is attached about halfway along the upper surface of the opisthotic. Although the superficial portion of the lower limb carries a sensory tube, the deeper portion of it must obviously, from its relation to the opisthotic bone, be regarded as the opisthotic limb. There may, in fact, be detected an indication of a separation into a more superficial and a deeper part at the posterior end of the limb. The supratemporal is remarkably large. It is a triangular curved lamina of bone which conceals the whole of the parietal, and parts of the frontal, squamosal, epiotic, and supraoccipital. The two supratemporals meet, or nearly meet, in the dorsal median line. The lower portion of the preopercular is large, and extends much lower than the subopercular. The interopercular is long and narrow, stretching from the front of the subopercular to the back of the mandible, so that it is considerably above the level of the lower edge of the preopercular.

Circumorbital Series (fig. 18).—There are nine bones of this series. The nasal is small and narrow, and the two postorbitals are large, and overlap the upper part of the preopercular.

Maxillary Series (fig. 18).—The gape is bounded above by both maxilla and premaxilla, and the premaxilla is exceptionally long. In a roughly prepared skull the maxilla appears to follow on immediately behind the posterior end of the premaxilla, but it really extends some distance forward along the inner surface of the premaxilla, and is thus overlapped by the premaxilla as it is in so many Malacopterygian fishes. Both premaxilla and maxilla carry a single row of teeth, those of the premaxilla being larger than those of the maxilla. There are no heads, either of the premaxilla or the maxilla, for articulation with the ethmoid region of the cranium, and the articulation with the palatine is of the feeblest character. There is no surmaxilla.

Mandibular Series (figs. 18 and 22).—The mandibular ramus is long and narrow, and the coronoid process low. The articular is small as compared with the dentary; its ectosteal and end-osteal constituents are clearly distinct, and a suture between the two appears on the external face of the ramus, which is very unusual (fig. 18). The sesamoid articular is comparatively

large. There is no distinct angular bone. The dentary is well toothed, the larger teeth being situated on the labial and lingual edges, the smaller teeth occupying the space between these two rows.

Hyopalatine Series (fig. 22).—The hyomandibular articulates with the cranium by two distinct heads ; its opercular head is long, and its axis slopes downward and backward. The angle between the symplectic and the axis of the hyomandibular is a little over a right angle. Teeth of fair size occur on the palatine and ectopterygoid, and small teeth on the middle part of the entopterygoid. The ectopterygoid is slightly curved, but has no distinct angulation.

Opercular Series (figs. 18 and 22).—The opercular and sub-opercular bones are rather small as compared with the size of the skull. The branchiostegal rays are nine in number on each side. Six are attached to the ventro-external edge of the ceratohyal, one at the junction of the ceratohyal with the epihyal, and two on the epihyal. They form an evenly graduated series.

Hyobranchial Series.—The sides and upper surface of the remarkably large glossohyal consist of ectosteal bone. Examined from below, the anterior three-fourths of the interior are seen to be composed of cartilage, the posterior fourth of cartilage-bone. The latter is situated at a higher level than the first basi-branchial, and overlaps the anterior two-thirds of that bone. The glossohyal bears the largest teeth in the head; the large teeth occupy the edges of the upper surface, and the inter-vening space is occupied by small teeth. The parasphenoid teeth fit very neatly between the large glossohyal teeth, and form a prehensive apparatus from which there can be little escape.

A dentigerous membrane-bone covers the whole of the second basibranchial, the posterior third of the first basibranchial, and the anterior three-fourths of the third basibranchial. It forms a direct continuation of the dentigerous part of the glossohyal. The upper and lower hypohyals are approximately equal in size and are rather large. The urohyal, on the other hand, is small and short.

The third epibranchial has an ascending process, but the first and second have not ; the second and third pharyngobranchials,

however, instead of running horizontally, have an upward tilt, and are directed towards the summit of the first pharyngobranchial, a long, nearly vertical, rod-like bone, which here simulates a spicular bone and is attached to the side of the pro-otic. The fourth epibranchial is an expanded plate of bone, roughly triangular in shape.

Summary of the Characters of the Skull in the Families Mormyridæ, Notopteridæ, *and* Hyodontidæ.

The foregoing observations may be summarized as follows :— In *Notopterus, Hyodon,* and the Mormyridæ the parietals meet in the median line; teeth occur on the parasphenoid (although they are rudimentary in *Mormyrops* and absent in *Gymnarchus*); an orbitosphenoid is present, and the *cavum cranii* of the dried skull is continued through this bone to the ethmoid region. An opisthotic is present in *Notopterus*; it is exceptionally large in *Hyodon*; it is absent in the Mormyridæ. A basisphenoid is present in *Notopterus* and *Hyodon*, and in *Petrocephalus* and *Gymnarchus*, but not in the other Mormyridæ examined. The eye-muscle canal opens posteriorly by an oval foramen in *Hyodon*, but is blind posteriorly in *Notopterus* and the Mormyridæ.

The postfrontal is small in *Notopterus*, and does not form part of the articular facet for the head of the hyomandibular, whereas in *Hyodon* and the Mormyridæ it is larger and has the more normal relation; it is small, however, in *Gymnarchus*. A pair of diverticula of the swim-bladder, of fair size, occur on the sides of the basioccipital in *Notopterus* and *Hyodon*; their ventral and external walls are of strong fibrous tissue, but cranial bones form the dorsal and internal walls.   In the Mormyridæ the basicranial bones are normal.

In *Notopterus* and the Mormyridæ there is a large lateral cranial foramen bounded by the epiotic, squamosal, and exoccipital. This, in the Mormyridæ, is loosely covered over by the large, thin, scale-like supratemporal, but in *Notopterus* the supratemporal is so small that it fails to form a cover for the foramen. The lateral foramen is not present in *Hyodon*, but there is a cartilaginous tract, bounded by the parietal, epiotic, and squamosal. The supratemporal of *Hyodon* is large and scale-like, but it is firmer than that of the Mormyridæ; the

right and left supratemporals, also, nearly touch one another above the cranium, which is not the case in the Mormyridæ. There is a long, slender epiotic limb to the post-temporal in *Hyodon* and the Mormyridæ (except *Gymnarchus*), but this is wanting in *Notopterus*.

The nasal is a strong, curved, grooved bone in *Notopterus* and *Petrocephalus*, but in *Mormyrops, Mormyrus*, and *Gymnarchus* it is more slender, though still conspicuously grooved, while in *Hyodon* it is a delicate tubular bone of small size. The circumorbital bones are, on the whole, much reduced in the Mormyridæ. In *Notopterus* the suborbitals are rather strongly developed; in *Hyodon* it is the postorbitals which have attained the greater development. The inwardly directed processes of the suborbital bones of *Notopterus* for articulation with the prefrontal and the ectopterygoid respectively are not represented in *Hyodon* and the Mormyridæ.

The surmaxilla is wanting in all. The gape is premaxilla-maxillary in *Notopterus* and *Hyodon*, the maxilla being well toothed up to near its posterior extremity, but in the Mormyridæ the gape is small and bounded above by the premaxillæ only, and the maxillæ are edentulous. The right and left premaxillæ are fused in the Mormyridæ (the fusion is not complete in *Gymnarchus*), which is not the case in *Notopterus* and *Hyodon*. The angular bone is distinct and of large size in *Notopterus*; in *Hyodon* and the Mormyridæ there is no separate angular.

The hyomandibular articulates with the cranium by a single broad head in *Notopterus*, and by two distinct heads in *Hyodon*; in the Mormyridæ the whole of the upper edge of the hyopalatine arch is in close relation with the cranium, and the cranial head of the hyomandibular projects very slightly, if at all, above the upper edge of the metapterygoid. A separate symplectic bone and a separate entopterygoid are recognizable in *Notopterus* and *Hyodon*, but not in the Mormyridæ. The palatine is fused with the ectopterygoid in *Notopterus*, but not in *Hyodon*, nor in the Mormyridæ. The palatine is fused with the side of the vomer in the Mormyridæ, but it is movably articulated, by a single head, in *Notopterus* and *Hyodon*.

In *Hyodon* the relations of the subopercular are normal, but the bone is rather small in size; in the Mormyridæ the sub-

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opercular is also small, tapers to a point posteriorly, and, except in *Gymnarchus*, is concealed by the opercular; in *Notopterus* the subopercular is wanting.

Considerable differences are to be noticed in the hyobranchial skeleton. A single small hypohyal, probably the upper of the two normally present, is to be found in *Notopterus*, and the same holds true for *Petrocephalus*, but in the other Mormyridæ examined there is no trace of a hypohyal. In *Hyodon* the upper and lower hypohyals are both present; they are large and approximately of the same size.

In *Notopterus* the first basibranchial is unossified, which is not the case in *Hyodon* and the Mormyridæ. In the Mormyridæ there is a large bone which either represents the first basibranchial alone or the first basibranchial and the endosteal glossohyal combined; beneath this the urohyal is immovably fixed or is fused. The urohyal in *Notopterus* and *Hyodon*, however, is freely movable, and has the usual paired ligament in front; in *Hyodon* the bone is quite small.

In *Hyodon* the hypobranchials are normal; in *Notopterus*, also, they are normal, but there are in addition a pair of tendon-bones projecting downward and outward from the posterior end of the second basibranchial; in the Mormyridæ the first hypo-branchials are extremely short, and the second hypobranchials small and confluent with the equivalents of the paired tendon-bones of *Notopterus*. These tendon-bones are not represented in *Hyodon*.

The first pharyngobranchial of *Notopterus* is cartilaginous; it is also unossified in *Petrocephalus* and *Gymnarchus*, but in *Mormyrus* and *Mormyrops* it is ossified, though small; in *Hyodon* it has the form of a long, upright rod of bone, simulating a spicular bone.

Comments on the Skull of the
Mormyridæ, Notopteridæ, *and* Hyodontidæ.

On the whole, the study of the craniological characters impels one to the conclusion that the families Mormyridæ, Notopteridæ, and Hyodontidæ, though more closely related *inter se* than is either family with any other family of Malacopterygian fishes, are not more intimately related with one another than was previously assumed to be the case. As has been seen from the summary immediately preceding, the cranial characters of the

families are so conflicting, that any phylogenetic arrangement based upon them is out of the question. The three families must remain, as hitherto, the terminals of a radiating system.

As Boulenger points out (Proc. Zool. Soc. 1898, p. 778), the Mormyridæ cannot rightly be grouped with the Ostariophysi of Sagemehl as Jordan and Evermann (Fish. N. Amer. i. 1896, p. 114) have done, since they possess no Weberian ossicles nor other modification of the anterior vertebræ. The absence of a separate symplectic in both Mormyroids and Siluroids is evidently nothing more than a matter of convergence: the symplectic is absent also in the Eels. The study of the skull of the Mormyroids shows also that they can have no close affinity with the Esocidæ, with which family Johannes Müller associated them. According to Boulenger the nearest allies of the Mormyroids are to be found in the Albulidæ, as suggested by Valenciennes in 1846 (Hist. Nat. Poiss. xix. p. 225 and p. 324).

I regret that the study of the skull brings forward no evidence in favour of this contention. While the Mormyridæ are highly specialized in certain respects, it must be admitted that they retain some primitive features. Of these, the presence of an orbitosphenoid and the meeting of the parietals in the median line are two, but they do not point to any closer resemblance between the Mormyridæ and the Albulidæ than with any other primitive family.

The presence of parasphenoidal teeth in most Mormyroids, in which respect the family agrees with the Albulidæ, may be regarded as another primitive feature retained by both families from the ancestral Teleosteans, a feature which might well be retained by two even strongly diverging families. Although in *Albula* there is no limitation of the freedom of lateral movement of the hyopalatine arch, the arch is certainly in fairly close contact with the cranium along the whole of its upper edge, and in this respect exhibits some resemblance to the condition found in the Mormyridæ; but the feature is an adaptive one, not uncommon in fishes that have a parasphenoidal and lingual dentition well developed, or that can bring the floor of the mouth forcibly against the palate.

The bounding of the upper border of the mouth by the premaxillæ alone and the absence of teeth on the maxillæ are specialized characters affected by numerous families of Tele-

osteans not genetically related, whenever, for some reason or other, a reduction in the size of the mouth takes place.

Of the other characters mentioned in the summary on p. 201 as distinctive of the Mormyroid skull, these are all characters of specialization, and throw no light on the question of affinity with the Albulidæ. The presence of a distinct symplectic in *Albula*, and a distinct entopterygoid, the presence of teeth on the vomerine, palatine, and pterygoid bones, the freedom from fusion of the palatine with the vomer, and of the right with the left premaxilla, the presence of a surmaxilla, the absence of reduction of the subopercular and of the hypobranchial skeleton, the possession of as many as 15 branchiostegal rays instead of 4–8, the existence of a separate glossohyal, the normal character of the urohyal, and the possession by the post-temporal of an opisthotic limb attached to a distinct opisthotic bone, all these are characters that one would naturally expect to see in any Malacopterygian fish of more archaic constitution than a Mormyroid.

On the other hand, the large lateral cranial foramen, covered by a thin scale-like supratemporal, so constant in the Mormyridæ, and the large paired tendon-bones that project down from the side of the second basibranchial are not represented in the Albulidæ; while the roofing of the posterior temporal fossæ and the presence of subtemporal fossæ (lying ventral to the posterior part of the facet for the head of the hyomandibular), characters which *Albula* possesses in common with the Elopidæ and Cyprinidæ, are not to be found in the Mormyridæ. The inflation of the hinder part of the base of the cranium of *Albula* is also not recognizable in the Mormyridæ, although, curiously enough, it occurs in *Notopterus*.

Concerning the genera *Notopterus* and *Hyodon* there is but little to be said, except that the latter possesses a greater proportion of primitive characters. Of the forms described in the present paper, there can be little doubt that the Mormyridæ are the most specialized, and *Hyodon* the least specialized; but the close study of the skulls of these fishes does not lend support to a view of relationship recently expressed by Boulenger. On p. 116 of his book 'Les Poissons du Bassin du Congo,' 1901, he writes :—" Les Notoptérides me semblent occuper vis-à-vis des Hyodontides une position analogue à celle qu'occupent les

Mormyridæ vis-à-vis des Albulides, c'est à dire qu'ils peuvent en être considérés comme modification excentrique." In considering the possibility of evolution of the Notopteridæ from the ancestral *Hyodon*, one must not lose sight of the fact that *Notopterus*—in the presence of the large lateral cranial foramen bounded by the squamosal, epiotic, and exoccipital, in the attempt (a futile one, it is true) of the thin scale-like supratemporal to cover it, and in the presence of a paired tendon-bone of considerable size projecting down from the side of the second basibranchial—exhibits characters strikingly constant in the Mormyridæ, but not possessed by *Hyodon*.

Although in both *Notopterus* and *Hyodon* there are vesicles of the swim-bladder on the lateral face of the otic region of the cranium, it does not necessarily follow that these structures have had a common origin. The connection between the swim-bladder and the ear must not be relied upon too implicitly as indicating close relationship between such fishes as possess it. That it has arisen independently in different groups is evident from the remarkable difference between the methods by which the result is arrived at. Compare, for instance, *Clupea* on the one hand and the Ostariophysi on the other. Stannius (Handb. d. Anat. d. Wirbelth. i. p. 2) mentions that there is a connection between the swim-bladder and the ear in the Macruridæ among the Anacanthini, and in the Berycidæ and Gerriidæ among the Acanthopteri; while Sagemehl (Morph. Jahrb. x. 1885, p. 51, footnote) observes that it occurs in the Gadidoids *Physiculus* and *Uraleptus,* and in the Scleroderm *Balistes.*

In conclusion, I wish to point out with some emphasis that the remarks in this paper apply to the skull only. I have purposely avoided all reference to other parts of the skeleton and to the soft structures of the body, since these were foreign to the investigation undertaken. The above deductions as to inter-relationships, therefore, cannot in any sense be regarded as final. It is hoped, nevertheless, that they may prove valuable as a contribution to a discussion of the affinities of the families concerned.

EXPLANATION OF THE PLATES.

PLATE 22.

Fig	1.	*Mormyrops deliciosus.*	Right side of skull (slightly enlarged).
	2.	,, ,,	Cranium, dorsal view (slightly enlarged).
	3.	,, ,,	Cranium, left side (slightly enlarged).
	4.	,, ,,	Hypopalatine arch of left side, with opercular bones and mandible, mesial aspect (slightly enlarged).

PLATE 23.

Fig.	5.	*Petrocephalus bane.*	Right side of skull ($\times 2$).
	6.	,, ,,	Cranium, dorsal view ($\times 2$).
	7.	,, ,,	Cranium, left side ($\times 2$).
	8.	,, ,,	Cranium, back view ($\times 2$).
	9.	,, ,,	Hypopalatine arch of left side, with opercular bones and mandible, mesial aspect ($\times 2$).
	10.	*Mormyrus caschive.*	Right maxilla ($\times 2$). *a*, horizontal, posteriorly directed process; *b*, process lying immediately over the posterior part of the premaxilla; *c*, antero-ventral edge, namely, that along which teeth might be expected to occur.
	11.	*Gymnarchus niloticus.*	Right ramus of mandible, mesial aspect ($\times \frac{2}{3}$).

PLATE 24.

Fig.	12.	*Notopterus kapirat.*	Right side of skull (nat. size).
	13.	,, ,,	Cranium, dorsal view (slightly enlarged).
	14.	,, ,,	Cranium, left side (slightly enlarged).
	15.	,, ,,	Cranium, back view (slightly enlarged).
	16.	,, ,,	Hypopalatine arch of left side, with mandible, mesial aspect (nat. size).
	17.	,, ,,	Hyobranchial skeleton, dorsal view. The epibranchials and pharyngobranchials of the right side are not shown (nat. size).

PLATE 25.

Fig.	18.	*Hyodon alosoides.*	Right side of skull (nat. size).
	19.	,, ,,	Cranium, dorsal view (slightly enlarged).
	20.	,, ,,	Cranium, left side (slightly enlarged).
	21.	,, ,,	Cranium, back view (slightly enlarged).
	22.	,, ,,	Hypopalatine arch of left side, with opercular bones and mandible, mesial aspect (nat. size).

D. Macbeth, Sc.

SKULL OF MORMYROPS.
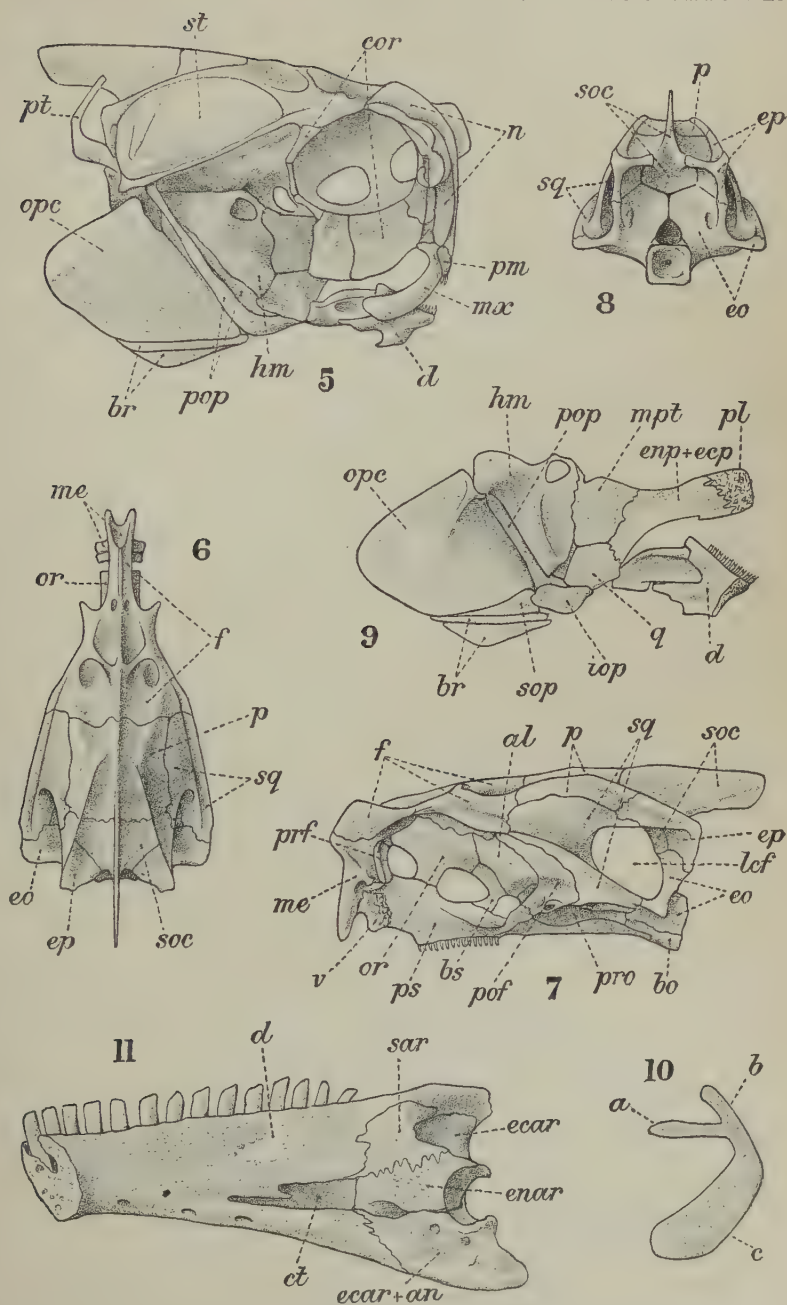
Figs. 5-9. PETROCEPHALUS; Fig. 10. MORMYRUS;
Fig. 11. GYMNARCHUS.
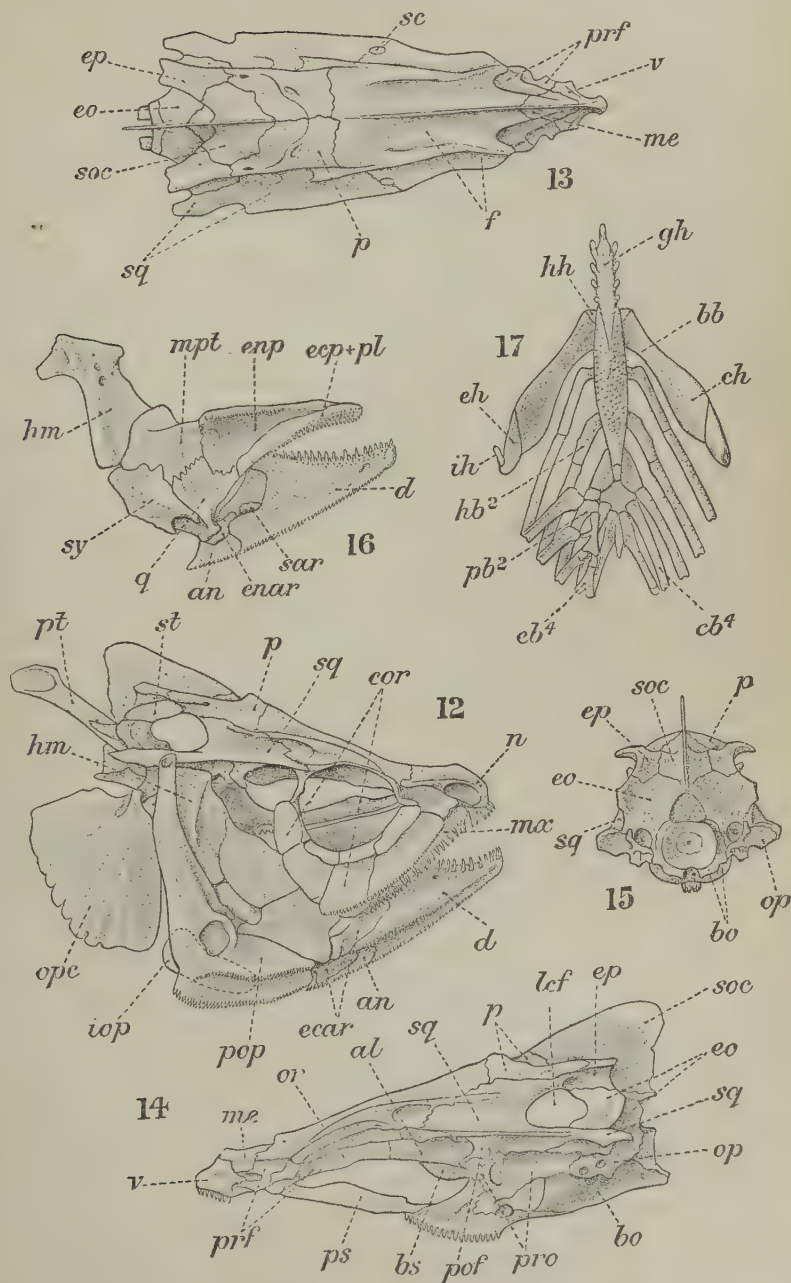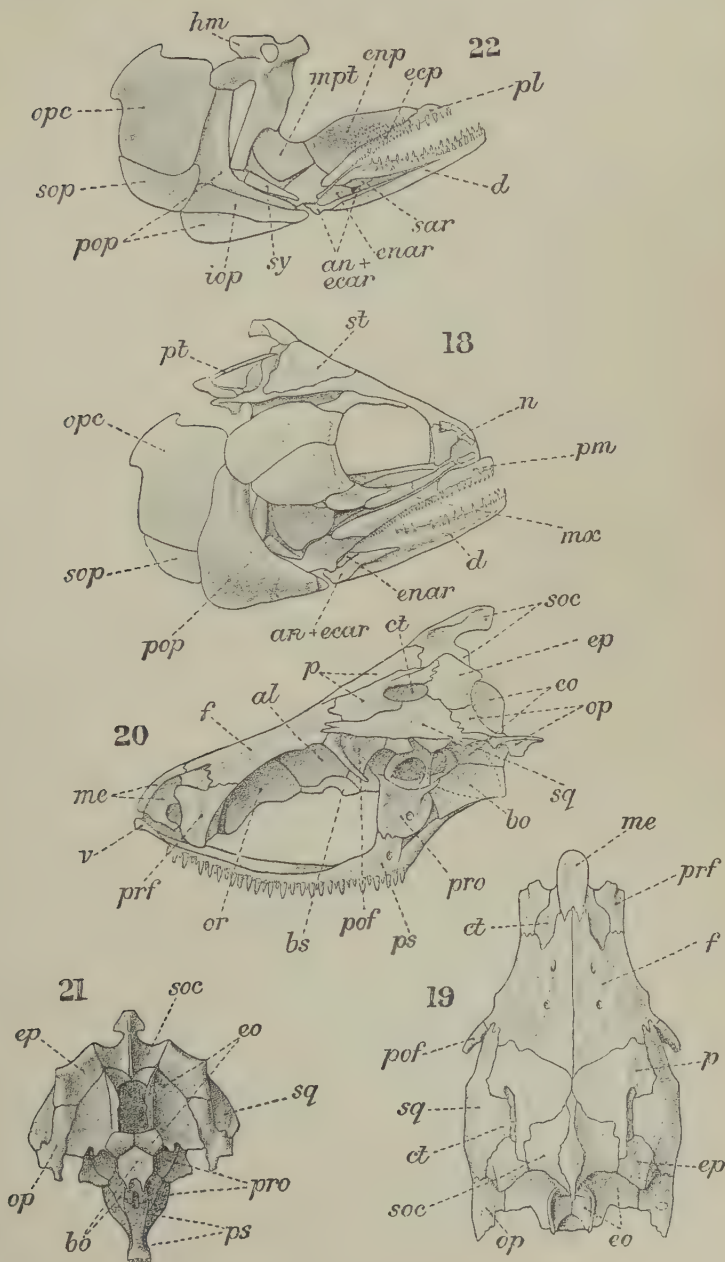
J. Green, del.   D. Macbeth, Sc.

SKULL OF HYODON.

Abbreviations employed in the Figures.

a,b,c ... (see explanation of fig. 10).
al ... alisphenoid.
an ... angular.
bb ... dentigerous plate covering the basibranchials.
bo ... basioccipital.
br ... branchiostegal rays.
bs ... basisphenoid.
cb ... ceratobranchial.
ch ... ceratohyal.
cor ... circumorbital bones.
ct ... cartilage.
d ... dentary.
eb ... epibranchial.
ecar ... ectosteal articular.
ecp ... ectopterygoid.
eh ... epihyal.
enar ... endosteal articular.
enp ... entopterygoid.
eo ... exoccipital.
ep ... epiotic.
f ... frontal.
gh ... glossohyal.
hb ... hypobranchial.
hh ... hypohyal.
hm ... hyomandibular.
ih ... interhyal.
iop ... interopercular.

lcf ... lateral cranial foramen.
me ... mesethmoid.
mpt ... metapterygoid.
mx ... maxilla.
n ... nasal.
op ... opisthotic.
opc ... opercular.
or ... orbitosphenoid.
p ... parietal.
pb ... pharyngobranchial.
pl ... palatine.
pm ... premaxilla.
pof ... postfrontal.
pop ... preopercular.
prf ... prefrontal.
pro ... pro-otic.
ps ... parasphenoid.
pt ... post-temporal.
q ... quadrate.
sar ... sesamoid articular.
sc ... foramen traversed by sensory canal.
soc ... supraoccipital.
sop ... subopercular.
sq ... squamosal.
st ... supratemporal.
sy ... symplectic.
v ... vomer.

On some New and Little-known British Freshwater Rhizopoda.
By JAMES CASH, Manchester. (Communicated by JOHN
HOPKINSON, F.L.S.)

[Read 16th June, 1904.]

(PLATE **26.**)

IN my investigation of the Rhizopodous fauna of this country
I have met with numerous forms, chiefly in the lowland
districts of Cheshire, and in Epping Forest, Essex, which
do not appear to have been yet recorded as British, and
some which are new to science. Mid-Cheshire contains low-
lying areas of bog or morass, the home of many rare plants,
both phanerogamic and cryptogamic. These places are always
richest in Rhizopoda. Testaceous forms occur in consider-
able abundance, in wet *Sphagnum*, and amongst the rootlets
of such mosses as *Philonotis fontana* and *Aulacomnium palustre*,
the conditions favourable to their development being for the
most part constant. The genera represented are *Difflugia*,
Nebela, *Hyalosphenia*, *Heleopera*, *Quadrula*, and others of the
lobose type, whilst the Euglyphina occur also in great variety
and perfection. Most remarkable, perhaps, are some naked
reticularian Rhizopods, of which one is described herein under
the generic name *Penardia*. A second, and closely allied form,
may be referable to the same genus, but its place cannot be
determined without further study.

Mid-Cheshire is remarkable for the number of old marl-pits
which are thickly scattered over extensive districts. These har-
bour rhizopodous life in great variety. *Pseudochlamys patella*,
Microgromia socialis, *Vampyrellæ*, and numerous forms of
Amœba, besides various species of *Acanthocistis* and other
Heliozoa, luxuriate amongst the surface-vegetation; whilst the
ooze abounds in *Pelomyxa palustris* and *P. villosa*, associated in
two or three localities with *Mastigamœba aspera*, E. Schulze,
and a variety of testaceous forms, such as *Arcella* and *Centro-
pyxis*. One of the most remarkable species met with in the
summer of 1903 was the *Amœba* described under the name of
A. pilosa, sp. nov. *Difflugiella apiculata*, gen. et sp. nov., is
the type of another proposed new genus, of which the pseudopodia
are a distinguishing feature. This and a new species of *Vam-
pyrella* were from the same locality, near Barking, Essex.

With regard to the distribution of the Rhizopoda generally, no definite law seems to prevail. Species inhabiting our own bogs and pools are common alike to Arctic and Temperate regions. Forms of *Lecquereusia* recorded from such widely separated localities as the Rocky Mountains and New South Wales do not vary in any essential feature from British examples. Neither climate nor altitude seems to affect them. The Rhizopodous fauna of the Eastern and Western Hemispheres is practically identical.

Few, if any, species can be said specially to affect alpine situations. The only ones, in my own experience, less common in lowland than in alpine districts are *Ditrema flavum*, Arch. (= *Amphitrema flava*, Penard*), and *Amphitrema stenostoma*, Nüsslin † (*A. Wrighteanum*, Arch., in part.). These scarce forms were met with on Cader Idris. Archer, however, discovered them in different localities in Ireland, which can hardly be described as alpine or sub-alpine.

Professor G. S. West, in his interesting record of the plankton of the Scottish lochs, mentions a number of species occurring in deep water. Most of them (*Clathrulina*, of course, being an exception) are denizens of *Sphagnum* bogs. The open waters of a lake can hardly be considered their natural home. It is quite conceivable, however, that they may have been washed out of the *Sphagnum* and other mosses growing on the banks, or conveyed by currents from the shallow waters of the lake-margins.

Some observations on new and little-known forms of Heliozoa must form the subject of another paper.

Class *RHIZOPODA*.

Order AMŒBINA.

Family LOBOSA.

Genus AMŒBA, *Ehrenberg*.

AMŒBA PILOSA, sp. nov. (Pl. 26. fig. 8.)

Animal resembling an average-sized *A. villosa*, with the same pale-bluish or neutral-tinted finely granular endoplasm, and containing, as in that species, a variety of food-corpuscles, mostly

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* 'Faune Rhizopodique du Bassin du Léman,' 1902, p. 538.

† Zeitschr. für wiss. Zool., Bd. xl.

green, together with refringent yellowish or brownish oil-like globules. Nucleus pale, situated in the anterior region ; contractile vesicles one or more.

The posterior extremity is produced into a delicately fringed expansion of faintly granular ectoplasm, in which are usually one or two clear vacuoles, the external outline being irregular and occasionally lobate. Including this posterior expansion, the entire body of the animal is closely beset with rigid hair-like processes, or spicula, radiating outwards, and resembling those which clothe the membranous test of *Cochliopodium vestitum*. This latter character distinguishes *A. pilosa* from all other forms of *Amœba*. Locomotion is effected by lobular expansions of the ectoplasm, anterior or lateral. As in *A. proteus* or *A. villosa*, the pseudopodia may originate at any point on the body-surface, but have never been observed to become digitate.

Dimensions : length about 180μ ; average breadth 50μ.

In ponds at Chelford, Cheshire, amongst the matted foliage of *Utricularia* and a species of water *Ranunculus* ; also at Fearnhead, Lancashire, in similar situations, 1903.

It is difficult to explain either the origin of the spicula which invest the body of this *Amœba*, or their mode of attachment to the soft protoplasmic surface over which they are very evenly, and at the same time thickly, distributed. Immediately a pseudopodal lobe is formed, the cil-like processes flow over it from the surrounding surface.

This organism was usually found associated with *Mastigamœba aspera*, E. Schulze. The Fearnhead examples presented some differences of habit, though agreeing in the pilose character. They were probably older individuals. The spicula were usually stouter and darker in colour; the endoplasm was denser ; the posterior appendage was absent, and the animal was more sluggish in its movements.

Genus MASTIGAMŒBA, *Eil. Schulze.*

MASTIGAMŒBA ASPERA, *E. Schulze*, Archiv für mikr. Anat. Bd. xi. p. 583, t. xxxv. ff. 1–3. (Pl. **26**. figs. 3, 4.)

In various localities in Cheshire and Lancashire ; Chelford, Northen Etchells, Fearnhead, 1903.

Dimensions: length, when fully grown, $150–250 \mu$; greatest breadth 100μ.

The facial aspect of *Mastigamœba aspera* is totally different

from that of *Amœba proteus* or *A. villosa*. It attracts attention
at once by its strikingly refringent ectoplasm. Besides this dis-
tinctive feature the organism is remarkable for the possession of
an anterior flagellum, 0·06 to 0·08 mm. long, according to
Hertwig and Lesser, which these authors rightly describe as
" a very fine filament of equable but hardly definable character,
and considerable refractive power." It is " not diminished at the
apex, but ends as if abruptly cut off." In all the Cheshire
examples met with this organ was so transparent and so fine
as to be with difficulty distinguished; in some it was imper-
ceptible; but in every case, where seen, it was in a constant
state of activity, so much so that it was impossible to bring
it into focus at once throughout its whole length. The organ
was not used for purposes of locomotion. The movements of
the animal are truly amœboid; although very young and small
examples were seen to effect a slight jerky movement from side
to side.

Usually two contractile vacuoles may be seen embedded in the
densely granular endoplasm, in the posterior region—one on each
side of the body. The entire body-surface has the remarkable
peculiarity, in adult individuals, of being covered, more or less,
with a thin stratum of extremely minute bacilliform bodies,
probably siliceous, and secreted during growth. Sometimes
these are hardly perceptible, and in young individuals they are
either absent or few in number.

The body of *Mastigamœba aspera* often assumes an irregularly
spherical or elliptical shape, with radiating pseudopodia of
variable length, in which condition the animal presents a totally
different appearance from that of the same individual *en marche*.
It then closely resembles the figures of *Dactylosphærium vitreum*.
The resemblance, indeed (aided by the refringent character of the
protoplasm), is so striking, that one can hardly avoid the con-
clusion, as was long ago suspected, that the two are phases of
the same organism. In what may, for convenience, be called the
D. vitreum phase, *Mastigamœba aspera* never exhibits a flagellum.
An individual is figured (fig. 4) in which, though here concealed,
this organ was distinctly visible so long as the animal was in its
normal condition—that is to say, *en marche*. Frequently small
and apparently young examples are met with which preserve
the *D. vitreum* form, and exhibit only superficial changes, for
considerable periods. In recovering from this condition the

animal thrusts out, first, the frontal lobe, with its flagellum, which is followed immediately by thin transparent pseudopodia, two or more on either side. These anterior pseudopodia are more mobile, as a rule, than the lateral ones, and are likewise more pellucid, because less thickly covered with bacilliform spicula.

Some Northen Etchells examples, examined last year, presented a remarkable variation from the type. This variation may or may not be permanent. Should such differences as were noted prove, on further examination, to be persistent, they may justify the constitution of this form into a new species (*M. cestriensis*, MS.). The animals were smaller and more slender, and their anterior pseudopodia were narrower and more elongated, than those from Chelford. But the chief point of difference is in the possession of a posterior appendage, comparable to that of *Amœba villosa*, though of different structure. It took the form of a circular expansion of ectoplasm, finely granular in substance and more or less transparent, containing usually two or more small non-pulsating vacuoles, and beset with conical or acute, radiating, and persistent pseudopodia. A few minute spicula could sometimes be detected about the surface of the appendages, whilst they were absent from other parts of the body, or few and scattered. The nuclear mass, always occupying an anterior position, and often partially hidden by the densely granular protoplasm, was more angular in outline than in other examples ; and the flagellum was almost invariably active, seeming to perform the function of a tentacle. A wider band of comparatively clear ectoplasm was also noted.

Family Reticulosa.

Genus Gymnophrys, *Cienkowsky*.

Gymnophrys cometa, *Cienkowsky*, Archiv für mikr. Anat. xii. (1876) p. 31, t. 5. f. 25 ; *Blochmann*, Die mikros. Thierwelt des Süsswass. (1895) p. 14, t. i. f. 9.

Examples of this apparently very rare organism occurred in *Sphagnum* from Lindow Common, Cheshire, in 1903. They presented some variation from the published figures, but not of such a character as to admit of doubts as to their identity. The body was more spherical than oval—often with projections from the surface-outline ; and whilst the longer pseudopodia emanated from opposite poles, sometimes a few shorter lateral

ones were formed. The pseudopodal filaments were extremely fine, extended into the surrounding medium to distances often five or six times the diameter of the body, and anastomosed sparingly. The protoplasm of the body-mass and pseudopodia was colourless, or pale and faintly granular. Some of the finer filaments—usually simple ones—were exceedingly mobile.

The organism has since been met with more abundantly elsewhere.

Genus PENARDIA, gen. nov.

Body when at rest roundish or ovoid ; at other times expanded and, during progression, exceedingly mobile ; the endoplasm a deep chlorophyllous green, with a marginal band of ectoplasm ; the pseudopodal filaments slender, branching and anastomosing, ultimately forming a widely-spreading network. The ectoplasm greyish, granular; the finer filaments faintly granular, colourless. Nucleus inconspicuous or absent : contractile vesicles (one or more) usually near the periphery of the endoplasm.

PENARDIA MUTABILIS, sp. nov. (Pl. 26. figs. 1, 2.)

Body when at rest roughly ovoid, with almost inert branching and anastomosing pseudopodia projected from the surface ; the central mass opaque or semiopaque, without definite structure. When *en marche* the animal becomes exceedingly mobile, expanding, elongating, and contracting incessantly, and throwing out a widely-extending network of pseudopodia which are used for the capture of prey.

In this mobile state the body is flattened out and becomes transparent, exhibiting a central mass (having a well-defined general outline) of a bright green colour, consisting apparently of a great number of minute oval bodies, closely compacted, but, so far as is known, without a nucleus. The hyaline ectoplasm is of varying width and is but slightly granular, changing with the pseudopodal movements.

Dimensions : length of body, irrespective of pseudopodia, 130 to 200 μ, or more; breadth variable. Diameter when at rest averaging 80 μ.

Amongst *Sphagnum* in a small swamp in Epping Forest, on the right of the road leading to Copped Hall Lodge, from the Epping highway, associated with colonies of *Microgromia socialis* and with *Pompholyxophrys punicea*, Arch., &c., 1901.

The animal did not occur abundantly in the locality mentioned,

but all the individuals met with had the features described sufficiently well-marked. One was observed to be feeding on a species of rotifer, which was very plentiful in the same gathering. During the inception of one of these the body of the *Penardia* underwent considerable changes; it became congested and opaque, and the unoccupied pseudopodia, where not withdrawn into the general mass, were comparatively inert. After feeding, the animal would remain stationary, or with very little movement, usually for a considerable time.

Order VAMPYRELLIDA.

Genus VAMPYRELLA, *Cienkowsky.*

VAMPYRELLA FLABELLATA, sp. nov. (Pl. **26**. figs. 5, 6.)

Plasmodium very mobile, most frequently appearing as an ovoid or double convex elongated body, narrowed at the extremities, each extremity furnished with short pseudopodal filaments, mostly capitate. A few fine, elongated, straight (but inconstant) pseudopodia are sometimes projected from the body-surface. Not unfrequently the entire organism becomes remarkably elongated, as though a tapering pseudopodium had been thrust out from one side (fig. 6). This is induced by the adhesion of the plasma to some foreign object, whilst the animal continues its forward movement, the effect being to draw it out to a fine point, the frontal outline meanwhile becoming fan-shaped and fringed with short capitate rays, with which a few longer and finer non-capitate filaments are intermixed. In all the examples met with the body was pale, with little or none of the reddish colour characteristic of the *Vampyrellæ.*

Dimensions: length of the ovoid body 60–70 μ; average breadth about 20 μ. Length when elongated, from the convex frontal margin to the pointed extremity, 100 μ or over.

In a broad and sluggish stream crossed by the Barking and Purfleet highway, about a mile from Barking, Essex, associated with *Difflugiella*, &c., amongst surface-vegetation: Aug. 1901.

Order CONCHULINA.

Family ARCELLIDA.

Genus DIFFLUGIELLA, gen. nov.

Test ovoid; in transverse section circular, composed of chitinous transparent membrane; the body-protoplasm usually
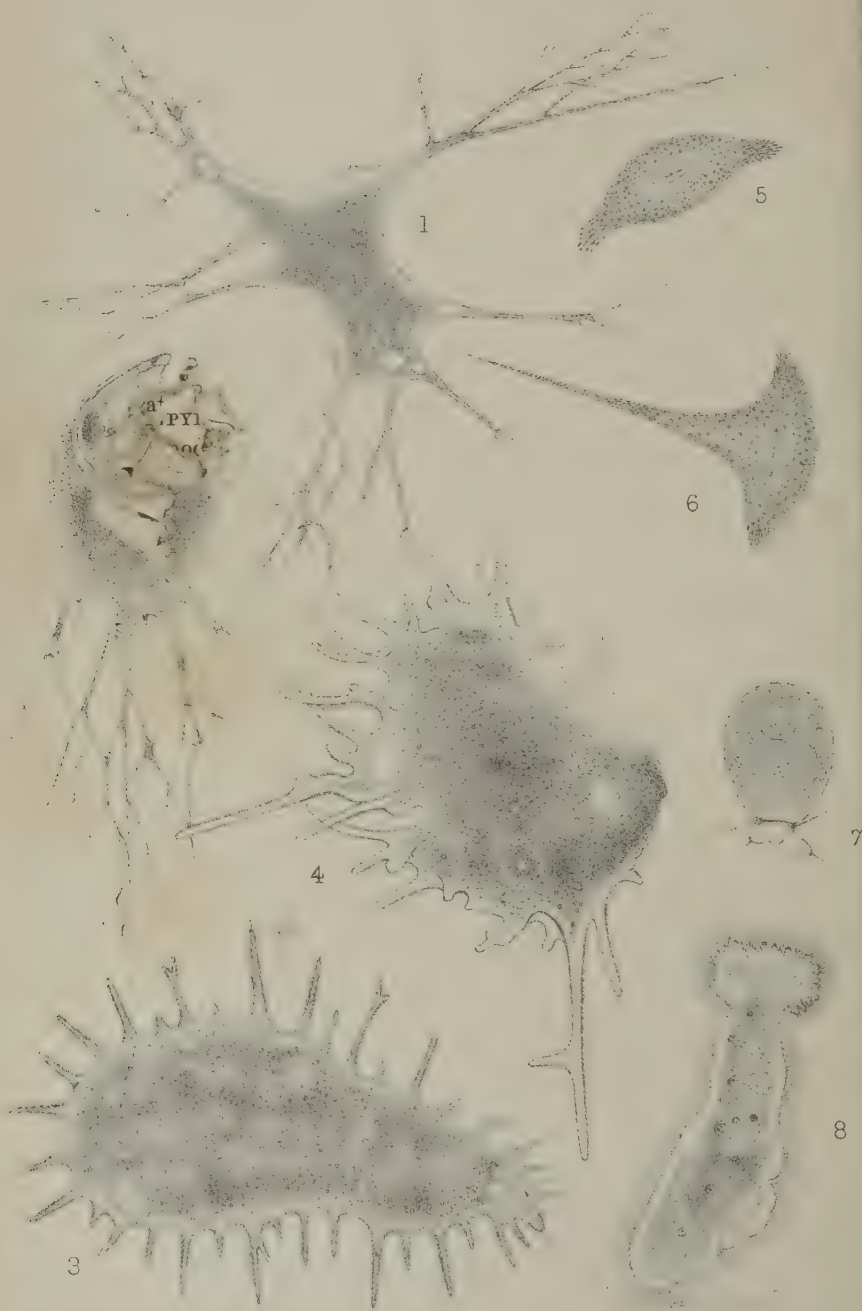
BRITISH FRESHWATER RHIZOPODA.

colourless, finely granular; pseudopodia of two kinds—one lobular or digitate, protruding centrally from the mouth of the test, and terminated by a short pointed apiculus; the others (two or more) projected laterally, straight, thin, and tapering.

DIFFLUGIELLA APICULATA, sp. nov.   (Pl. 26. fig. 7.)

Test ovoid in lateral view, membranous, smooth; the sides curving evenly from the crown downwards to the mouth. Endoplasm granular, colourless, or with a faint greenish tinge. The nucleus inconspicuous.

Dimensions: length of test 40 μ; greatest breadth 30 μ.

Amongst vegetation, chiefly floating algæ, in the stream above refered to, near Barking, Essex, May 1901.

The abnormal structure of the pseudopodia in this organism is its distinguishing feature. Individuals were kept under observation for a considerable time, and in all cases presented the same characters, showing conclusively that they were not accidental. The form of the mouth could not be made out, the membrane about it being apparently thin and flexible. The central digitate pseudopodia were always more or less active (the apiculus particularly so), whilst the lateral more elongated and acicular ones were comparatively rigid and changed but little.

EXPLANATION OF PLATE 26.

Figs. 1 & 2. *Penardia mutabilis*, gen. et sp. nov.   1, an active individual; 2, the same, after capturing a small rotifer. From Epping Forest. About × 350.

3 & 4. *Mastigamœba aspera*, E. Schulze. 3, an active adult individual, showing the flagellum; 4, another individual—temporary phase—in which the flagellum, though distinctly seen when the animal was active, is concealed. From separate localities in Lancashire and Cheshire. × 350.

5 & 6. *Vampyrella flabellata*, sp. nov. Characteristic phases of a single individual, when active. From Barking, Essex. × 500.

Fig. 7. *Difflugiella apiculata*, gen. et sp. nov. From Barking, Essex. × 500.

8. *Amœba pilosa*, sp. nov. From Chelford, Cheshire. × 350.

Note on some Points in the Structure of the Gill of the Ceylon
Pearl-Oyster. By W. A. HERDMAN, F.R.S., President.

[Read 3rd November, 1904.]

(PLATE 27.)

IN examining the structure of the gill in *Margaritifera vulgaris*,
Schum., for the purposes of my Report on the Ceylon Pearl-
Oyster Fisheries, I have come upon two little points which may
be of sufficient interest to be put on record *.

The first of these is the presence of extensive ciliated junc-
tions (1) in the median line between the inner gills of the two
sides, and (2) laterally between each outer gill and the mantle-
lobe.

In examining the living pearl-oyster the inner gills seem to be
united in the middle line, and the outer gills seem to be joined
to the mantle outside them. In dissecting a well-preserved
specimen, where there has been no marked contraction or dis-
tortion, the same apparent continuity is seen. Concrescence of
these originally separate parts seems to have taken place as in
many other Pelecypoda, such as most of the Eulamellibranchia.
On manipulating the gills, however, it is found that slight
pressure with dissecting-needles is generally sufficient to force
the parts asunder, and they are seen to separate with clean-cut
broad edges or seams and leave no appearance of tearing.
Figure (Pl. 27) 1 is a diagrammatic transverse section of both
ctenidia (the four " gills "), and the darker lines at *M.c.j.* and
L.c.j. show the junctions in question. Figure 2 is a dissection
of the right ctenidium separated at *M.c.j.* from its fellow of the
other side and at *L.c.j.* from the mantle, so as to show the
broad seams.

Transverse sections (such as figure 3) through the gills and
mantle show that the explanation of these adhesions, and yet
ready separation, is that the seams in the case of both gills and
mantle-lobes are covered with short stiff cilia which interlock to
form very effective and extensive ciliated junctions. Figure 4
shows the median one between the upturned ends of the inner
lamellæ of the inner gills. The gap in the centre is probably a
post-mortem separation of the two epithelial layers. Figure 5
shows the lateral junction between the reflected or outer lamina

* They are briefly referred to in Part II. of the Report to the Ceylon
Government (Royal Society, 1904).

of the outer gill (*g.f.*) and the inner surface of the mantle-lobe (*Pall.*). At these ciliated junctions the epithelial cells are cubical or low columnar with a distinct marginal band from which the very regular stiff cilia project (Pl. 27. figs. 4 a & 5 a).

It is interesting to note that in some, if not in all, specimens, at the extreme ventral end of the median ciliated junction between the two inner gills, the epithelial and connective tissues have united across the narrow passage (fig. 4, *org.*), and so true concrescence or continuous organic union has, at that point, replaced the ciliated junction.

In the Eulamellibranchia the ascending lamella of the outer gill is usually concrescent with the mantle, and the inner lamellæ of the inner gills are united in the middle line; but such junctions are quite exceptional in the Eleutherorhabda, and where they do occur there is an irregularity about their distribution, allied species showing very different conditions. Consequently it is interesting to find this new form of junction, which may be regarded as intermediate between perfect freedom and complete concrescence *. The presence of this ciliated form of junction, which allows of an easy separation of the opposed surfaces, may also account for the differences of opinion we find amongst authorities. Pelseneer gives as a character of the family to which the pearl-oysters belong that the branchiæ are joined to the mantle, and Ridewood says that in *Meleagrina vulgaris* and *M. margaritifera* there is no fusion with adjacent parts. My specimens, with their ciliated junctions, show the one or the other condition according to their state of preservation.

The second structural point I desire to record is the presence of somewhat extensive organic connections between the adjacent gill-filaments of a plica at the level of the ciliated discs.

Figure 7 shows the manner in which, as seen in a horizontal section across both ctenidia (four " gills," *o.g.* and *i.g.* on each side), the filaments are thrown into crests and troughs so as to form plicæ. In the trough between two plicæ lies a modified or

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* Ridewood (Phil. Trans. B. vol. 195, p. 194) has described, in the case of *Anomia aculeata*, patches of interlocking cilia by means of which the lower edges of the two inner gills are held together, and the lower edges of the outer gills are joined to the mantle. The filaments in this case, however, are not reflected, so the relations of parts are not the same as those described above in the Ceylon Pearl-Oyster; but the small patches in *Anomia* may be an indication of the same tendency to form ciliated junctions between adjacent parts.

" principal " filament (figs. 6, 7, 8, *p.f.*). At certain levels (fig. 6) the ordinary filaments are kept in position by pad-like thickenings, the ciliated discs (*c.d.*) bearing short stiff cilia which interlock. Dr. Ridewood, in his recent admirable memoir " On the Structure of the Gills of the Lamellibranchia " (Phil. Trans. B. vol. 195, 1903), has figured in *Avicula argentea* the simultaneous presence of ciliated junctions and true organic union of the filaments; and in stating that no other instance occurred in the whole of his extensive investigation, adds (p. 155, footnote), " except perhaps in *Meleagrina vulgaris*, the specimen of which was not sufficiently well-preserved to enable one to determine the point." The latter species is the Ceylon Pearl-Oyster and the *Avicula* is a closely allied species; and I can entirely agree with all that Dr. Ridewood has been able to determine in regard to these forms. All I am able to do is to add a little detail, and even that point of structure was probably suspected by Dr. Ridewood, although his material was not apparently in a condition to show it. In his memoir (p. 213), after describing the condition in *Avicula argentea*, he says :—" Possibly a similar cellular connection obtains in *Meleagrina vulgaris*." I can now state definitely that it is in that species, as Dr. Ridewood thought might possibly be the case. In examining a series of sections through the plicæ of well-preserved gills, it is easy to find groups of 2, 3, 4, or 5 filaments joined by continuous organic union—the growth of connective tissue and epithelium having, in these interfilamentar spaces, replaced or supplemented the usual ciliated junctions. Thus the two forms of junction exist side by side or form a compound union, and all degrees of formation of a complete cellular connection may be found (see fig. 12). It is scarcely possible, after examining such conditions, to doubt that ciliated junctions have preceded the organic union. Figure 11 shows two filaments joined by the compound of ciliated disc and cellular connection, and fig. 12 shows the presence together in the one plica, at the same level, of ordinary ciliated junctions and various degrees of organic growth. Since these figures were drawn I have found a specimen where all the twelve filaments of a plica were united by complete organic union (Pl. **27**. figs. 7 *c* and *d*). The concrescence is not always at the internal edges of the filaments, but may be about the middle of the former ciliated disc; and in one case I found two points of union between two neighbouring filaments leaving an ovate ciliated gap.

GILL OF CEYLON PEARL OYSTER.
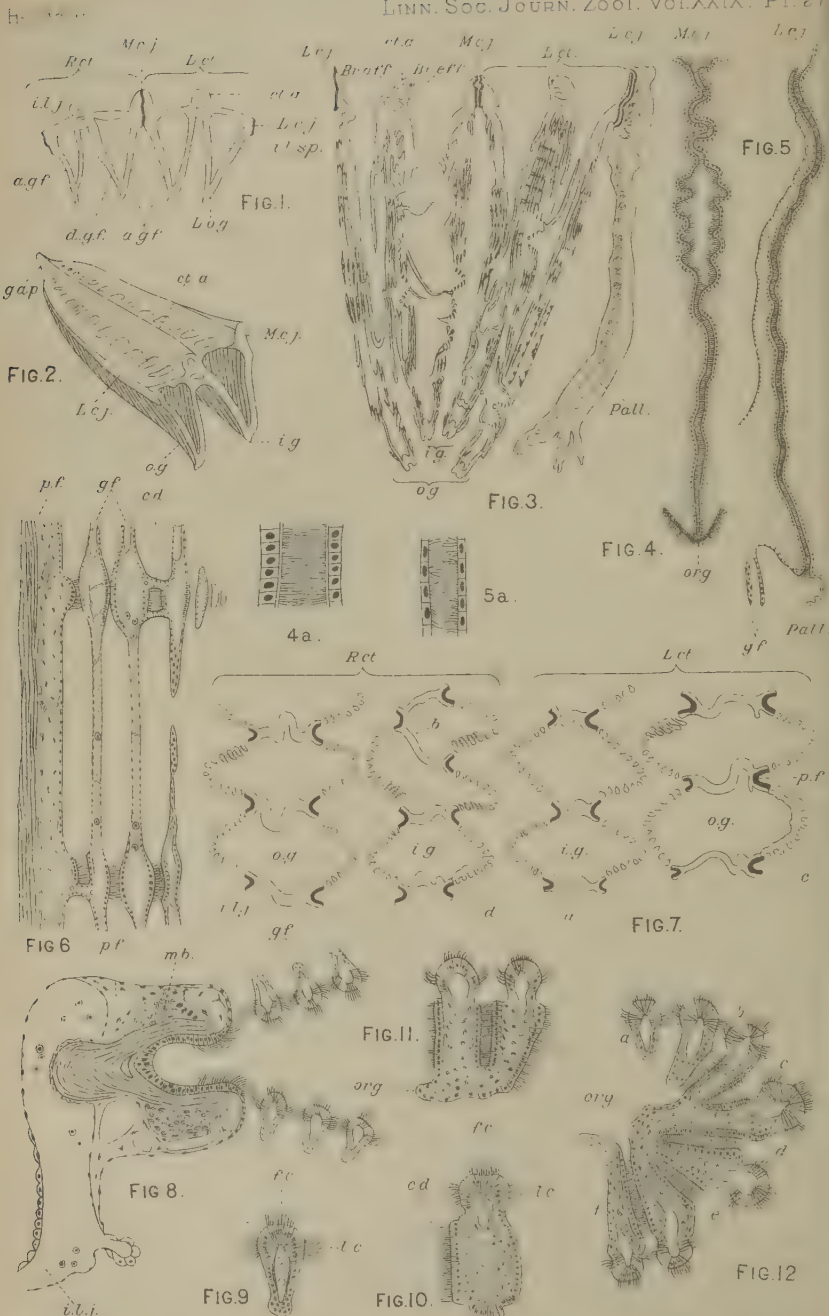
Organic interfilamentar junctions are characteristic of the Eulamellibranchia, and, as Ridewood has noted, "with one exception do not occur in the Eleutherorhabda." It is therefore of some interest to add the Ceylon Pearl-Oyster as another exception, and to find that in this character of the interfilamentar junctions, as well as in that taken from the connections of the gills with neighbouring parts, this member of the Eleutherorhabda shows an approach to the Eulamellibranchiate condition.

EXPLANATION OF PLATE 27.

Fig. 1. Diagrammatic transverse section through the two ctenidia of the Pearl-Oyster, to show the axes (*ct.a.*) and the position of the median (*M.c.j.*) and lateral (*L.c.j.*) ciliated junctions. × 2.

2. Dissection of left ctenidium showing the appearance of the median and lateral ciliated junctions. × 2.

3. Transverse section through left mantle-lobe and both ctenidia, to show the extent of the median and lateral ciliated junctions. × 15.

4. The median ciliated junction between the inner lamellæ of the inner gills : *org.*, slight organic connection. × 400. 4 a. Small part of the ciliated epithelium, enlarged.

5. The lateral ciliated junction between the outer lamella of the outer gill and the mantle-lobe (*Pall.*). × 400. 5 a. Small part of the ciliated epithelium, enlarged.

6. Longitudinal section along the gill-filaments, to show the ciliated discs (*c.d.*). × 50.

7. Horizontal section across the two ctenidia (four " gills," *o.g.* and *i.g.*). × 50.

8. Part of last more highly magnified to show the filaments in cross-section. × 400.

9. An ordinary gill-filament in transverse section. × 500.

10. Transverse section of a filament at the level of a ciliated disc (*c.d.*). × 500.

11. Section showing two filaments joined by organic union at the level of a ciliated disc. × 400.

12. Section showing a group of filaments joined by various combinations of organic union with ciliated discs. × 400.

Bryozoa from near Cape Horn.
By ARTHUR WM. WATERS, F.L.S., F.G.S.

[Read 3rd November, 1904.]

(PLATES **28** & **29**.)

THE specimens now described were brought back by the French
Mission Scientifique du Cap Horn, in the ' Romanche,' but they
do not appear to have been seen by Jullien when he wrote the
description of the Bryozoa*, and it may be that a part of the
material was not submitted to him.

The importance of any collection from S. America is now very
great, when collections from the Antarctic have been made by
several Expeditions, and must shortly be described, for com-
parisons have to be made with the fauna from South America,
this being the nearest land to the Antarctic, and it has even
been spoken of as Antarctic. As already explained in my
report † on the Bryozoa collected by the ' Belgica,' it was for the
purpose of making comparison with Antarctic Bryozoa that I
went to Paris to study some collections in the Muséum d'Histoire
Naturelle, including Jullien's collections ; and I have to thank
M. Gravier and Professor Joubin for allowing me to take away
some pieces for study and illustration. Besides the species
dealt with in the paper, most of which Jullien had probably not
seen, there are some mentioned by him which had been previously
described under other names, as :—

Membranipora coronata, Jull., is *M. incrustans*, Waters.
Andreela uncifera, Busk, is *Micropora uncifera*, Busk.
Lepralia collaris, Jull., is *Lepralia crassilabris*, Hincks.
Schizoporella rimosa, Jull., is *Schizoporella Ridleyi*, MacGill.
Exochella longirostris, Jull., is *Smittia tricuspis* (Hincks).
Aimulosa australis, Jull., is *Smittia marsupium*, MacGill.
Arachnopusia monoceros, Busk, is *Hiantopora monoceros* (Busk).
Osthimosia evexa, Jull., is *Osthimosia eatoniensis* (Busk).
Pedicellina australis, Jull., is *Barentsia discreta*, Busk.

The most interesting observation on structure is the occur-
rence of a thick membranous transverse wall or tabula at a

* "Bryozoaires," Mission Scientifique du Cap Horn, 1888.
† "Bryozoa," Expédition Antarctique Belge, 1904, p. 9.

moderate distance from the calcareous closure in *Entalophora regularis*, MacGill. At first the wall is entire, completely separating the upper and lower part of the zoœcial tube; at another stage it becomes funnel-shaped, and clearly the tentacles are then able to pass through it. This is one of the most important facts concerning the anatomy of the Cyclostomata that we have come across for a long time, and one requiring an examination in other Cyclostomata, for we are not yet able to explain its meaning, or its bearing on the calcareous " closures."

The present paper shows that the geographical distribution of several species is greater than had been previously supposed, and the following species were first described in the ' Challenger' reports :—

Membranipora falcifera, Busk, described from off the Argentine.

Cellaria variabilis, Busk, from Patagonia and Kerguelen Island.

Thalamoporella labiata, Busk, off the Argentine.

Cribrilina latimarginata, Busk, off the Argentine.

Haswellia auriculata, Busk, Tristan da Cunha and Cape of Good Hope.

Turritigera stellata, Busk, off the Argentine and Cape of Good Hope, also recently found in the Antarctic.

[Since this communication was read an important paper by Dr. L. Calvet, " Bryozoen," Hamburger Magalhaensische Sammelreise, 1904, has appeared, and I have added references without discussing any points raised.

I had decided to wait until Dr. Calvet's description of the Magellan collection was published, but when he was unable, through illness, to continue work for a time, it seemed better not to postpone the publication of mine any longer. Through Dr. Calvet's illness I was not aware that his paper had been completed and placed in the printer's hands.

My memoir on the Bryozoa collected in the Antarctic by the ' Belgica' was distributed very shortly after the completion of the description, though before the publication, of the Hamburg Magellan collection, and it has therefore happened that we have again, in some cases, both been dealing with the same species without either of us having the least wish to forestall the other.]

List of Species.

CABEREA BORYI, *Aud.*

For synonyms see Miss Jelly's Catalogue, and

Caberea Boryi, Jullien, Mission Scient. du Cap Horn, p. 75, pl. 13. fig. 5; Waters, Journ., Linn. Soc. Zool. vol. xxvi. p. 9; [Calvet, Bryozoen, Hamb. Magalh. Sammelreise, p. 7].

Busk, in his 'Challenger' Report, p. 29, described a closely allied species as *C. Darwinii*, and said that, so far as he knew, *Caberea Boryi*, Aud., is confined to the Mediterranean and Atlantic. In my paper on Cellulariidæ, mentioned above, I discussed these two species, and pointed out that *C. Boryi* occurs in New South Wales, Victoria, and New Zealand, and the specimens from the Cape Horn Expedition are *C. Boryi*, Aud., and not what I should call the variety *Darwinii*, Busk. The Cape Horn specimen is from No. 177, "entre l'île Navarin et l'île Hoste," 270 metres, $+7°·7$ C. [Smyth Channel, 8 fath.; Punta Arenas; Isla Picton, 4 fath.; South Georgia, *Calvet.*]

FLUSTRA OVOIDEA (*Busk*).

Carbasea ovoidea, Busk, Cat. Mar. Polyzoa, p. 52, pl. 50. figs. 5–7; Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 55, pl. 16. fig. 3.

Flustra ovoidea, Waters, Interzoœcial Communication in Flustridæ, Journ. R. Micr. Soc. 1896, p. 284, pl. 7. figs. 18, 19.

Carbasea ramosa, Jullien, Mission Scientifique du Cap Horn, p. 75, pl. 6. figs. 2, 3, 4.

[*Flustra ovoidea*, Calvet, Bryozoen, Hamb. Magalh. Sammel. p. 9.]

The size and shape of the zoœcia, as well as the position of the operculum in Jullien's *Carbasea ramosa*, is identically the same as in *C. ovoidea*, Busk, collected by the 'Challenger,' and the thicker wall on the front near the proximal end occurs in the Cape Horn specimens, as described by Busk, when he says "membranous aperture occupying the upper two-thirds of the front." In the Cape Horn specimens there are 15–16 tentacles and 4–6 lateral rosette-plates, and numerous distal pores. I previously gave two lateral rosette-plates for *C. ovoidea*, Busk, but on examining more satisfactory material it seems that I had taken the half of the wall for the complete wall.

Although the zoarial shape is not identical in *C. ovoidea*, Busk, and *Flustra ramosa*, Jull., the differences are not very important, and there is no doubt as to their identity.

Hab. Straits of Magellan; Patagonia; Kerguelen (*Busk*). Exp. Cape Horn: Baie Orange, Dredge 81, 26 met. [Smyth Channel, Long Island, 8 fath., *Calvet.*]

MEMBRANIPORA FALCIFERA (*Busk*). (Pl. 28. figs. 14, 15.)

Foveolaria falcifera, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 69, pl. 15. fig. 6.

Membranipora falcifera, Waters, Zool. Chall. Rep., Supp. vol. xxxi. pt. lxxix. p. 11.

This is apparently not uncommon, and grows on *Retepora*, *Aspidostoma*, &c., but no ovicells are found in any of the specimens from Cape Horn. There are large pores on the front of the zoœcium. The opening of the avicularium is characteristic (fig. 15), there being a narrow opening in the rounded portion, which becomes wider in the part under the mandible.

Hab. 'Challenger' Station 320 (off the Argentine), 600 fathoms. Cape Horn, Station unknown.

CELLARIA AUSTRALIS, *MacGill.*

Cellaria fistulosa, var. *australis*, MacGill. Zool. of Vict. dec. v. p. 48; Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. xiii. p. 368, pl. 14. fig. 4.

Cellaria australis, MacGill. Tr. Roy. Soc. Vict. vol. xxi. p. 93 (1884); Waters, Zool. Chall. Exp. vol. xxxi. pt. lxxix. p. 16, pl. 2. figs. 1, 4; MacGillivray, Tert. Polyzoa Vict. p. 29, pl. 3. fig. 19.

Salicornaria clavata, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 88, pl. 12. fig. 8.

Hab. Victoria; New South Wales; Bass's Straits; Kerguelen Island. Cape Horn Expedition, Station unknown.

Fossil. Victoria.

CELLARIA VARIABILIS (*Busk*).

Salicornaria variabilis, Busk, Zool. Chall. Rep. vol. x. pt. xxx. p. 89, pl. 12. figs. 3 & 9, fig. 7 in text.

The ovicellular opening is at first round, and subsequently the proximal end becomes straight.

Hab. Off Patagonia and Kerguelen Island (*Busk*). Cape Horn Exp., Station unknown.

MICROPORA BREVISSIMA, *Waters*.

Micropora brevissima, Waters, Expéd. Antarct. Belge, Bryozoa, p. 40, pl. 2. figs. 7 *a–c*.

THALAMOPORELLA LABIATA (*Busk*). (Pl. **29.** figs. 6–9.)

Vincularia labiata, Busk, Zool. Chall. Exp. vol. x. pt. xxx. fig. 73, and woodcut fig. 3.

Thalamoporella labiata, Waters, Zool. Chall. Exp. vol. xxxi. pt. lxxix. p. 13, pl. 1. fig. 23, pl. 2. figs. 12–15, 33.

Vincularia elegans, d'Orb., Voyage dans l'Amérique Méridionale, p. 21, pl. 9. figs. 25–28.

Vincularia ornata, Busk, Brit. Mar. Polyzoa, p. 96, pl. 65. fig. 2.

Before discussing the Cape Horn specimens it should be mentioned that d'Orbigny's specimen of *Vincularia elegans* in the Muséum d'Hist. Nat. Paris, is, on the whole, as figured by d'Orbigny, but in some zoœcia a growth from each side forms a calcareous bridge over the opesium (see Pl. **29.** fig. 9). The bridge is underneath the membrane to which the operculum is attached.

It seems to be by no means rare in the neighbourhood of Cape Horn, and while the bridge, just referred to, was not seen in any of the specimens collected by this Expedition, they otherwise entirely correspond with d'Orbigny's specimen, in which, however, the bridge is only found to a few zoœcia. The opesial opening is slightly longer and wider than that of the 'Challenger' *T. labiata*, Busk, and in the Cape Horn specimens there are a few minute denticles or hooks growing on the border of the opesium;

but, again, it is only on a few zoœcia that these are found, and I may add that it has been necessary to draw the spines unduly large, as the figure is but slightly magnified. In the *Vincularia ornata*, Busk, these spines are mentioned as being a constant character. Unfortunately the *V. ornata* is not in the British Museum collection, for a specimen in the Busk collection was found to have been so named by mistake.

There are no signs of ovicells, and in the sections cut there were no ova. There are 26 tentacles in the Cape Horn specimen. The opesial opening of *T. gothica* (Busk), of the 'Challenger,' is wider than that of any *T. labiata* examined, but the two are evidently very closely allied. However, it does not seem that Busk was justified in considering the 'Challenger' specimens as being the same species as d'Orbigny's Cretaceous fossil *Vincularia gothica*, d'Orb., as these last are very much smaller, the length and width of the zoœcia in specimens from Meudon (kindly sent to me by Mons. Canu) being about one-half, and the opesia are also much smaller. There is, however, in these fossil specimens a projection at each side of the opesium and one from the proximal edge. *Cellepora crustulenta*, Goldf., seems to me to be only an encrusting form of *Vincularia gothica*, d'Orb., as seen in a specimen from Moen, Denmark; and in both the erect and encrusting form there are onychocellaria but no small avicularia; whereas in *Thalamoporella gothica*, Busk, no onychocellaria have been seen, while there is a small avicularium.

The *Vincularia gothica*, d'Orb., is placed under *Floridina* by both Jullien and Canu, but I am by no means satisfied that there are sufficient grounds for separating *Floridina* from *Onychocella*, but whether we are right in placing the present form with *Thalamoporella* time will show. *T. Rozieri*, Aud., the type of the genus, has external ovicells. A specimen sent to me as *Onychocella* (*Vincularia*) *disparilis*, d'Orb., fossil from the Cretaceous of Moen, Denmark, has similar opesia to the recent *T. labiata*, B., and to one zoœcium there is a narrow bridge; the fossil has onychocellaria, and our further examination of *labiata* suggests its being very nearly allied to *Onychocella*.

The various specimens of *T. labiata*, Busk, show how more ample material may modify our ideas, for occasionally there may be a bridge and occasionally spines, and these have been noted by some authors, and species based on these characters.

Hab. Cape Horn and Falkland Islands, 160 metres (*d'Orb.*); Patagonia, as *ornata* (Busk); off the Argentine, 600 fathoms (*Chall.*). Cape Horn Exped., St. 170, Canal Franklin, June 27th, 1883, 95 metres; Murray Narrows, 200 metres; and Station unknown.

CRIBRILINA PATAGONICA, sp. nov.   (Pl. **28**. figs. 6, 7.)

Zoarium adnate upon *Aspidostoma giganteum*, Busk.   The zoœcia are elongate, ovate, distinct, convex; below the aperture there is an area with 5–7 radiating raised ribs, having between each a pore near to the border. The oral aperture has the lower edge straight, the distal end rounded, and the sides straight; the operculum has on each side a flange projecting inwards. Above the distal border of the oral aperture there is an elevated triangular avicularium directed laterally. The ovicell is large, globose, carinate.   There are no vicarious avicularia in the pieces examined, but nevertheless it no doubt belongs to the *C. figularis* group, and in some respects is like *C. clithridiata*, Waters, but differs in the shape of the aperture of the ordinary zoœcia, though the ovicelligerous aperture of *C. clithridiata* is not very dissimilar. The *C. patagonica* is much like the fossil *C. Ungeri*, Reuss, and in many particulars is very similar to the *Membraniporella magellanica*, shortly to be described by Calvet. Whether that species should be placed under *Membraniporella* is decidedly an open question. [It varies from the description of *M. magellanica* in having supra-oral avicularia directed laterally, and in the opercula having flanges. Further, I have not found the "interzoœcial Höhlungen" mentioned by Calvet.]

Hab. Cape Horn Expedition, Station unknown.

CRIBRILINA LATIMARGINATA, *Busk*.

Cribrilina latimarginata, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 131, pl. 22. fig. 10; Waters, op. cit. vol. xxxi. pt. lxxix. p. 22, pl. 1. figs. 11, 12, 18; [Calvet, Bryozoen, Hamb. Magalh. Sammelreise, p. 18].

I am able to add three new and interesting localities from specimens in the Paris Muséum d'Histoire Naturelle.

Hab. Off the Argentine, 600 fathoms (*Busk*).   178 *a*, Mus. d'Hist. Nat., on *Hornera* (*americana*, d'Orb.), collected by M. Petit-Thouars in the French 'Vénus' Expedition, off the Falkland Islands. On the specimen of *Fasciculipora ramosa* figured by d'Orbigny, No. 13735; Falkland Islands.   Cape

Horn Expedition, D. 188, Sept. 14th, 1883, 135 metres, north of Falkland Islands. [East Patagonia, 80 fathoms, *Calvet*.]

MICROPORELLA HYADESI (*Jullien*). (Pl. 28. figs. 1–5.)

Fenestrula Hyadesi, Jullien, Mission Scientifique du Cap Horn, p. 44, pl. 4. fig. 7.; [Calvet, Bryozoen, Hamb. Magalh. Sammelreise, p. 21].

There are several pieces from Cape Horn from unknown stations; and also in the Muséum d'Histoire Naturelle in Paris there are several (Nos. 260 *a*, 261 *a*) collected from the Falkland Islands by M. du Petit-Thouars, in the French ' Expédition de la Vénus.'

The bilaminate zoarium is large, foliaceous, either contorted or with large flat pieces, out of which similar flat pieces grow at right angles, anastomosing and forming rectangular cavities. In the Falkland Island and the Cape Horn specimens there are ovicells, whereas Jullien's single small specimen contained none. The ovicell is much raised, globular, finely granular, and below it (proximally) there is a separate bridge over the aperture, being formed by a calcareous growth from the two sides meeting in the middle.

There are many cases of Bryozoa having a bridge below the aperture, but no other species has been described in which it seems to belong to the ovicell, in the same way as in this species. In some ovicells the distance between the bridge and the ovicell is slight, and then at first sight it might be taken for part of the ovicell.

The surface of the zoœcium is granular and perforate. The operculum has the proximal border notched to correspond with the crenulated border of the aperture. The mandible is slightly winged at both sides, somewhat resembling that of *Diporula hastigera*, B. The median pore is denticulate (fig. 2).

Hab. Lat. 53° 13' S., long. 68° 31' W., 97 met. (*Jullien*); off the Falkland Islands (*Mus. d'Hist. Nat.*); Station unknown. [East Patagonia, lat. 44° 32' S., long. 61° 25' W., " deep sea"; Cape Blanco, 80 fath., *Calvet*.]

SCHIZOPORELLA PATAGONICA, sp. nov. (Pl. 28. figs. 8–11.)

Zoarium adnate. Zoœcia ovate, convex, granulate, with an acute avicularium directed upwards on each side of the aperture. Above the oral aperture there are six spines, some of which are

flat, club-shaped, often dentate at the ends, other spines are very long and thin. The oral aperture has a very distinct sinus which expands at the lower border, the distal end of the aperture is round. The operculum is thicker at each side and is thinner down the centre, the opercular muscles are attached at some distance from the border.

Hab. Cape Horn Expedition, Station unknown. Growing on *Aspidostoma giganteum*, Busk.

HIPPOTHOA DIVARICATA, *Lamouroux*.

For the distribution of this cosmopolitan species see my "Bryozoa" in Expéd. Antarctique Belge, p. 53, pl. vii. fig. 3.

HIPPOTHOA DISTANS, *MacGill*.

This is also widely distributed. See op. cit. p. 54, pl. iii. figs. 8 *a–g*.

HASWELLIA AURICULATA, *Busk*.

Haswellia auriculata, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 173, pl. 24. fig. 10; Waters, op. cit. vol. xxxi. pt. lxxix. p. 31, pl. 3. fig. 38; Jullien & Calvet, Bryozoaires prov. des campagnes de l'Hirondelle, p. 145, pl. 17. fig. 3.

Vincularia pentagona, d'Orbigny, Voyage dans l'Amérique Mérid. p. 21, pl. 10. figs. 4, 6.

? *Porina grandipora*, Waters, Quart. Journ. Geol. Soc. vol. xliii. p. 59, pl. 7. fig. 23.

Although this species was first described by d'Orbigny, the name given by Busk must be retained *, as the original description was insufficient, and I had no idea that *auriculata* and *pentagona* were identical until I saw d'Orbigny's specimens. The generic name *Haswellia* is used with reserve of any opinion as to its being permanently retained.

Hab. Tristan da Cunha, 75–150 fath.: Cape of Good Hope, 150 fath.; Falkland Islands, No. 13617, Mus. d'Hist. Nat. Paris (*d'Orb.*); Azores, 130 met. (*Jull. & Calv.*). Cape Horn Exp. C. H. 658, and dry pieces; Station unknown.

SMITTIA SPINOSISSIMA, *Hincks*.

Specimens from Cape Horn have the small zoœcia with recumbent smooth ovicells, the wide plate or denticle in the oral aperture, and the pores round the border sometimes seen as

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* [A decision which will not command universal assent.—SEC. L.S.]

tubes, just as in the *S. spinosissima* of Hincks. This group of *Smittia* is most difficult to determine, and this species approaches so closely to *S. Peachii* var. *octodentata*, Hincks, that I considered they were the same; but Hincks did not agree in this (see Ann. Mag. Nat. Hist. ser. 6, vol. ix. p. 327), and possibly the wide denticle is a sufficiently important character on which to base the separation.

Hab. Bass's Straits. Cape Horn Exped., Station unknown.
Fossil. New Zealand (*Waters*).

SMITTIA LANDSBOROVII, form PERSONATA, *Hincks.*

This species, which is fairly common from Cape Horn, and was described by Jullien as *S. monacha*, Jull., has been dealt with more fully in my "Bryozoa," Exp. Antarct. Belge, p. 63.

Hab. Bass's Straits; Victoria; New South Wales; Cape Verde Islands; Marion Islands. Cape Horn, Station unknown.

SMITTIA ALVAREZIANA (*d'Orbigny*).

Escharina alvareziana, d'Orb. Voyage dans l'Amérique Mérid. p. 14, pl. 6. figs. 1–4.
Reptescharellina alvareziana, d'Orb. Pal. Fr. Terr. Crét. p. 453.
Mucronella alvarezi, Jullien, Bull. Soc. Zool. de France, p. 5 (1881).
Mucronella alvareziana, Waters, "Tert. Bry. New Zeal." Quart. Journ. Geol. Soc. vol. xliii. p. 57, pl. 7. figs. 24, 25 (1887).
Lepralia alata, Busk, Brit. Mus. Cat. p. 71, pl. 79. fig. 3.

In the specimen found among the material collected by the Cape Horn Expedition there are 5 spines, and in the New Zealand fossil there are 5 or 6, whereas Jullien saw none, nor does d'Orbigny describe any. The two outer spines in *S. alvareziana* are rather larger than the others, and these may have dropped off in Busk's *L. alata,* which corresponds in other respects, but unfortunately it has been impossible to make direct comparison, as *L. alata* was not returned to the British Museum.

There is an umbo and denticle to some zoœcia, but there are others without either.

Hab. Bolivia and Peru (*d'Orb.*); Valparaiso (*Jull.*) on *Ostrea*; Cape Horn, 40 fath., as *alata* (*Busk*). Cape Horn Exp., Station unknown, on *Aspidostoma giganteum,* Busk.

Fossil. New Zealand.

SMITTIA LEBRUNI, sp. nov. (Pl. 28. figs. 13 & 13 *a, b, c*).

The zoarium forms large foliaceous masses with a bilaminate

growth, having the same form as *Microporella Hyadesi*, Jull.; and both resemble *Lepralia foliacea*, Ell. & Sol., in zoarial growth.

The zoœcia are elongate, ovate, very slightly convex, with pores over the surface, the pores near the border frequently being the largest. The peristome usually meets in front, forming a large pore below, there is a wide denticle in the oral aperture, and below the distal border there is a crenulated arched shelf. Near to the oral aperture there is a spatulate avicularium, which, however, is sometimes replaced by one having a large wide avicularian chamber, giving the zoœcium a very inflated appearance. The mandibles of these avicularia are wide, with the distal arc rather less than a half-circle.

The ovicell is slightly raised and perforated. There are two distal rosette-plates, and three large lateral ones to each lateral wall.

This is in some respects similar to *Smittia antarctica*, Waters, but is quite distinct.

Although I have rarely given personal names, on account of the difficulty they frequently occasion to naturalists of other countries, yet I have made an exception, and named this after the collector, as names of most of the other members of the staff were used by Jullien.

Hab. Station unknown, and St. 32, lat. 53° 73′ S., long. 68° 31′ W., 97 met., +6°·6 Cent.

Smittia sp.

There is a small specimen which corresponds with *S. marmorea*, Hincks, but there are no ovicells, and there are several spines round the oral aperture. The small triangular avicularium below the aperture is often directed diagonally downwards.

Cellarinella dubia, *Waters.*

Cellarinella dubia, Waters, Expéd. Antarct. Belge, Bryozoa, p. 58, pl. 8. figs. 12 *a*, *b*, and fig. 2 in text.

The Cape Horn specimens were referred to in my Antarctic Report.

Hab. Antarctic (*W.*); Patagonia; Tierra del Fuego; Straits of Magellan.

Exped. Cape Horn: Station 4, lat. 50° 52′ S., long. 67° 36′ W., 140 met., 5°·7 Cent.; Entre l'île Navarin et l'île Hoste, 270 met., 7°·71 Cent.

LAGENIPORA ROTA (*MacGillivray*).

Cellepora rota, MacGillivray, Trans. Roy. Soc. Vict. vol. xxi. (1885) p. 116; Prod. Zool. Vict. dec. xv. p. 184, pl. 148. fig. 3.

It is very doubtful whether this should not be called *Lagenipora Costazii*, Aud., for though the operculum is somewhat longer and thicker, it is of the same type as that of the Mediterranean *L. Costazii*. MacGillivray certainly seems to have made a slip when describing *C. Costazii* * from Victoria, for his species has a small central avicularium below the mouth, and has not, as a rule, the pair of long elevated avicularia. *L. rota*, on the other hand, has the pair of avicularia, and very closely resembles the European *L. Costazii*. Some authors have been misled by the mistake now pointed out.

Hab. Victoria (*MacGillivray*). Cape Horn Exp., Station unknown.

LAGENIPORA LUCIDA, form NITENS, *MacGillivray*. (Pl. 29. figs. 15–18.)

Lagenipora nitens, MacGillivray, Trans. Roy. Soc. Vict. vol. xxiii. (1887) p. 180, pl. 1. fig. 1; MacGillivray, Prod. Zool. Vict. dec. xvi. p. 209, pl. 156. fig. 3.

Zoarium pisiform. The differences from typical *L. lucida*, Hincks, are but very slight; but as the present form more nearly corresponds to MacGillivray's figure than is the case in most specimens of *L. lucida*, attention is called to the fact. It, however, has 10 tentacles, whereas the *L. lucida* from Madeira has 12, and the mandibles of the vicarious avicularia differ somewhat from those from Madeira, as the sides are straighter. The avicularian tube is usually median, but is sometimes diagonal as figured by MacGillivray. The ovicells are globular, with a very small area.

Lagenipora lucida is widely distributed.

Hab. Victoria. Cape Horn, Station unknown.

CELLEPORA PETIOLATA, sp. nov. (Pl. 29. figs. 19, 20.)

The zoarium starts from a very small stalk, then spreads out, forming a club-shaped colony.

The zoœcia are perforate, having a few large pores, porcellanous, with a long rostrum supporting at the end a triangular

* Prod. Zool. Vict. dec. xv. p. 185, pl. 148. figs. 5, 6. *Multescharella globulosa*, d'Orb. Pal. Fr. vol. v. p. 458. Specimen 13691, Algiers, in d'Orbigny's Coll. in the Mus. d'Hist. Nat. Paris, is *Lagenopora Costazii*, Aud.

avicularium, and the narrow acute mandibles have a long characteristic lucida. The zoœcia resemble those of *Cellepora hastigera**, Busk, but the shape of the operculum shows that they are quite distinct. The operculum is very thin, which is unusual in *Cellepora*, and the shape of the proximal edge shows that it fitted into a wide sinus, which cannot be usually seen in the zoœcia on account of being concealed by the calcareous growth. There are 13–14 tentacles.

I have already referred to this species when describing *Orthopora compacta*†, Waters, and mentioned how the zoarial growth of the two species corresponds, so that at first I was misled into believing them to be the same species; but the shape of the operculum proved that they were quite different, and *O. compacta* has 24 tentacles, whereas the present species has only 13 or 14.

Though the name *Cellepora* is here used, it is recognised that many species now called *Cellepora* may have to be removed elsewhere.

Hab. Cape Horn Exped., Station No. 32; lat. 53° 13′ S., long. 68° 31′ W.; 97 met., +6°·6 Cent.

TURRITIGERA STELLATA, *Busk.*

Turritigera stellata, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 130, pl. 24. fig. 1; Waters, op. cit. vol. xxxi. pt. lxxix. p. 22, pl. 1. figs. 22, 25; Waters, Expéd. Antarctique Belge, Bryozoa, p. 76, pl. 5. figs. 3 *a–c*, pl. 8. fig. 13.

Among the Cape Horn material there is a small and worn fragment, which, however, was just sufficient to show the specific characters.

Hab. Off the Argentine, 600 fath. (*Busk*); Cape of Good Hope, 150 fath. (*Busk*); various Antarctic Stations, 435–569 metres (*Waters*). Cape Horn Exp., Station unknown.

RETEPORA MAGELLENSIS, *Busk.*

Retepora magellensis, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 126, pl. 36. fig. 20; Waters, op. cit. vol. xxxi. pt. lxxix. p. 22, pl. 3. fig. 5.

As I have previously pointed out, Busk's description of *R. magellensis* requires correction, as in the 'Challenger' and other specimens there are distinct vibices and also semicircular avicularia on the dorsal surface. Probably this is the *R. cellu-*

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* Zool. Chall. Exp. vol. x. pt. xxx. p. 192, pl. 29. fig. 1.
† Expéd. Antarct. Belge, Bryozoa, p. 76.

losa of Ridley, and the figure 7 of pl. 123 of Busk's Brit. Mus. Catalogue, which, however, is not referred to in the text. There are 14 tentacles.

Hab. Off Argentine, 600 fath.; Falkland Islands (*Busk*). Cape Horn Expedition, Station 4, lat. 50° 52′ S., long. 67° 36′ W., 140 met., +5°·7 Cent.; and Station unknown.

RETEPORA SPATULIFERA, sp. nov. (Pl. **29**. figs. 4, 5.)

The specimen from Station No. 4 has narrow strap-shaped branches, which anastomose irregularly; but other specimens, with very similar zoœcia, have the zoarium regularly reticulate. On the anterior surface, below the aperture, there is a round avicularium close to the oral slit, also there are round avicularia on the front of the zoœcium, usually one or two to each zoœcium. The pair of oral spines are articulated, and usually, in the specimen from Station 4, become very wide towards the end, having the same shape as the club-shaped spines of *Microporella spatulifera,* Smitt, as figured in my paper * on "Bryozoa from Franz-Josef Land," and the specific name is chosen on account of this similarity.

The ovicell, which is but slightly raised, has a fissure down the middle. I am not aware that the ovicell of typical *R. magellensis,* Busk, has been described; but it occurs with a fissure in specimens from the Straits of Magellan shortly to be described by Calvet †. In *R. spatulifera* the dorsal surface is divided by vibices, has numerous small openings and round avicularia. There are 13–14 tentacles.

This is very similar to *R. magellensis,* Busk, in most particulars, but in the specimen from Station 4 differs in the shape of the branches and in their irregularly anastomosing; though in the specimen from Station 167 the zoarium is reticulate, as in *B. magellensis,* and the articulate spine is more delicate, being seldom club-shaped.

Hab. Cape Horn Expedition: Station 4, lat. 50° 52′ S., long. 67° 36′ W., 140 met., +5°·7 Cent.; Station 167, Ile Grevy, 65 met., +3°·0 Cent.

ASPIDOSTOMA GIGANTEUM (*Busk*). (Pl. **29**. figs. 1–3.)

Aspidostoma giganteum, Busk, Zool. Chall. Exp. vol. x. pt. xxx. p. 161, pl. 33. fig. 3; Waters, op. cit. vol. xxxi. pt. lxxix. p. 28, pl. 1. figs. 16–

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* Journ. Linn. Soc., Zool. vol. xxviii. pl. 12. fig. 6.   † See above, p. 231.

18, pl. 3. figs. 20, 21 ; Ortmann, "Invertebrate Fossils from Patagonia," Amer. Journ. of Sci. ser. 4, vol. x. p. 368 (1890).

Eschara gigantea, Busk, Brit. Mus. Cat. p. 91, pl. 119. fig. 3 ; Jullien, Mission Scientifique du Cap Horn, p. 77, pl. 6. figs. 5, 6.

Aspidostoma crassum, Hincks, Ann. Mag. Nat. Hist. ser. 5, vol. vii. p. 160, pl. 10. fig. 6 (1881); MacGillivray, Tert. Polyzoa of Victoria, p. 102, pl. 13. fig. 12.

Steganoporella patula, Waters, Quart. Journ. Geol. Soc. vol. xxxvii. p. 265, pl. 9. fig. 31 (1882).

Micropora cavata, Waters, Quart. Journ. Geol. Soc. vol. xxxix. p. 435.

Specimens from Cape Horn are sometimes broadly foliaceous, sometimes reticulate with the fenestræ large, attaining to 20 mm. by 10 mm.; all seem to be bilaminate.

The operculum forms a thick sac, and has a projecting knob at each proximal corner (as figured in my 'Challenger' Supp. Rep. pl. iii. fig. 21), to which are attached muscles. At the proximal edge of the oral aperture there is a lamina rising at right angles to the operculum, and proximally to the lamina there is a hollow space into which the "elongate callosity" of Hincks may project as a mucro. A hollow space of this kind occurs in several genera of Bryozoa, and the zoœcium is contracted thereby. The loop-shaped openings at each side are for the knobs of the opercula, and are in no way similar to the opesiules of *Micropora*, &c. through which a muscle passes.

The zoœcia are connected distally through long tubes, which frequently have a dividing disk in the middle (Pl. **29.** fig. 2), and sometimes the tubes bifurcate. The number of these tubes is usually 8, representing as many rosette-plates, and there are about 6–9 lateral rosette-plates *.

* The name "origella" given by Jullien "à tous les bourgeons de l'endocyste, depuis l'état rudimentaire jusqu'au moment où le bourgeon dévient un zoïde quelconque" (Miss. Scient. du Cap Horn, p. 12), has never seemed to me to be required. There are growing and vital tissues in different forms, from which sometimes new zoœcia are formed, or which pass through the pore-tubes to the surface. The growing tissue, when new zoœcia are being formed, is, from time to time, separated by disks at intervals and in different ways, according to the species. These are the rosette-plates, or septules of Jullien, and their form and other peculiarities furnish useful characters.

Jullien (' Bryozoaires provenant des campagnes de l'Hirondelle,' Jullien & Calvet, p. 18) says that I have stated the rosette-plates to be the equivalent of his "origelles." This is a misunderstanding of what I said, which was that the rosette-plates represent the origella, by showing to us, not only in living, but also in fossil and dried specimens, the position of the origella. The rosette-

There are 20–23 tentacles, but the state of preservation of the piece I prepared was not favourable for further detailed examination.

The " pent-house projection " above the aperture is not, as a rule, well marked, but a small projection can be made out on most zoœcia. The large reticulation recalls *Petralia undata*, MacGill., which, from a specimen in the Paris Museum, seems to be the species named *Retepora ambigua* by Lamarck.

Loop-shaped openings at the lower corner of the oral aperture may be formed in two ways : firstly, as in the present case, for opercular projections ; secondly, as in *Rhagasostoma*, where the operculum has a straight lower edge and is carried by the covering membrane over the opesial opening.

Aspidostoma airensis, Maplestone, has been found fossil in Victoria.

Hab. Patagonia ; Falkland Islands ; Tristan da Cunha, 110–150 fath. (*Busk*). Cape Horn Expedition, Station unknown ; and between Falkland Islands and the Straits of Magellan, 100–200 metres. [Straits of Magellan, *Calvet.*]

Fossil. Victoria (*Waters & MacGill.*) ; South Australia (*Waters*) ; Santa Cruz and Santa Julian, Patagonian formation, as Miocene (*Ortmann*) *.

ADEONELLA LICHENOIDES (*Lamarck*). (Pl. 28. fig. 12.)

Eschara lichenoides, Lamk. Anim. sans Vert. vol. ii. p. 176 (1816) ; Milne-Edwards, 'Sur les Eschares,' p. 31, pl. 2. fig. 3 (1836).

Adeona punctulata, Jullien, Miss. Sc. du Cap Horn, p. 86, pl. 4. fig. 6 (1888).

Adeonella atlantica, Busk, Zool. Chall. Exp. vol. x. pt. 30, p. 186, pl. 20. fig. 7, pl. 21. figs. 1, 1 *b* (1884) ; Waters, op. cit. vol. xxxi. pt. 79, p. 33, pl. 2. figs. 20, 37.

plates, by serving as the sign of the way in which this tissue has grown, are of great importance.

Beania magellanica, Busk, has the zoœcia distant but connected by tubes, and this shows us how the rosette-plates are formed : processes of the ectocyst grow at any of the six positions where connecting-tubes may occur and contain growing tissue ; they spread out and join with their neighbours, and at an early stage rosette-plates are formed. An exact drawing of an actual specimen is given in my paper " On the Bryozoa of the Bay of Naples," 1879, Ann. Mag. Nat. Hist. ser. 5, vol. iii. pl. xii. fig. 1.

[* Canu, in his paper just published on " Les Bryozoaires du Patagonien. Mém. Soc. Géol. de France, vol. xii. p. 14, calls this *A. Ortmanni*, Canu.]

The present form certainly seems to be the *Adeonella lichen-oides* of Milne-Edwards, who presumably examined the specimens described by Lamarck. It, however, is not the *A. lichenoides* of Busk's 'Marine Polyzoa,' to which he subsequently, in the 'Challenger' Report, p. 180, gave the name *tuberculata* *, which will probably be found to be superfluous. The *Eschara lichen-oides* of Heller is no doubt *Schizoporella serratimargo*, Hincks, also described by Neviani as *S. sulcata*. Neviani now calls it *Schizotheca serratimargo*, Hincks. (*Schizotheca serratimargo*, Hincks, *rett. di nomen.*, Boll. Soc. Geol. Ital. vol. xxiii. p. 270, 1904.)

The spirit-specimen from the Cape Horn Expedition, D. 174, "S.E. de l'Ile de Scott," has few pores over the surface, a round median pore, and an avicularium by the side. Milne-Edwards did not speak of the surface pores, and only calls the surface "lissé"; however, in other cases where there are pores he did not mention them. At the side of the branches of the Cape Horn specimens the ordinary zoœcia are replaced by large avicularia with triangular mandibles, and this is a character of the species. There are 14 tentacles.

Hab. Indian Ocean (*M.-Edwards*); Tristan da Cunha, 75, 110 fath. (*Busk*); Tierra del Fuego (*Busk*). Cape Horn Exped., Station 174, S.E. de l'Ile de Scott; and Station unknown.

* In 1864, Reuss described and figured an *Adeonella* from the Mayence Basin as *Eschara tetrastoma* (Sitzungsb. k. Ak. Wissensch. Wien, vol. 50. p. (9), pl. ii. fig. 2), and the same year Stoliczka figured some much worn fossils from Orakei Bay, New Zealand, as *Flustrella clavata*, Stol. I examined a few very small foliaceous fragments from Curdies Creek, S.W. Victoria, which I figured as *Microporella clavata*, Stol., but some better preserved branching specimens were described as *M. yarraensis*, Waters (Q. J. Geol. Soc. vol. xxxvii. p. 331, pl. xv. figs. 27, 28). MacGillivray, who has since had ample material, says that *clavata* and *yarraensis* are synonyms, the species being very variable. This is somewhat surprising, as besides having a different zoœcial growth, the zoœcial characters seen appeared sufficient to justify separation; however, as MacGillivray was a very careful observer, we must presume that he was correct (see Tert. Polyzoa Vict. p. 70, pl. ix. figs. 15, 18). About the same time MacGillivray described a recent specimen as *Adeonellopsis parvipuncta*, and here we find the outside or lateral zoœcia with an elongate denticulate pore, while the ovicelligerous zoœcia have an area with several round denticulate pores. This, to a large extent, explains the difficulty there has been in the determination of the fossils, for the different structure of the two sets of zoœcia has only recently been understood, though first described by Milne-Edwards. The *A. lichenoides*, Busk, of the Brit. Mus. Cat., is therefore *A. clavata*, Stol.= *A. yarraensis*, Waters=*A. parvipuncta*, MacGill.=*A. tuberculata*, Busk= ? *A. tetrastoma*, Reuss.

DIASTOPORA CONCINNA, *MacGillivray*.

Tubulipora concinna, MacGill. Trans. Roy. Soc. Vict. vol. xxi. (1885) p. 94, pl. 1. fig. 10.

Growing on *Aspidostoma giganteum*, Busk, the zoaria are at first flabelliform, and then become circular in older stages.

The zoœcial tubes are small, free, projecting, perforated all over, and no closures with tubules are seen. The ovicell is a small round inflation, with the ovicellular tube turned back towards the centre of the zoarium, but without a funnel in the specimens examined, whereas in what I have considered to be *D. latomarginata*, d'Orb., from Capri it is very marked.

The divisional lines between the zoœcia are very distinct, and the internal diameter of the zoœcia is about 0·06 mm.

Probably this is what has sometimes been called *D. latomarginata*, d'Orb., though the ovicells usually spread more laterally in *D. latomarginata*, and there are tubules to the closures, and it may therefore be better to suspend judgment as to the identity of the two.

Hab. Victoria; New South Wales.   Cape Horn, Station unknown.

ENTALOPHORA PROBOSCIDEA (*M.-Edwards*).

For synonyms see Miss Jelly's Catalogue, and
Entalophora proboscidea, Waters, Expéd. Antarct. Belge, Bryozoa, p. 91, pl. 9. figs. 4 *a*, *b*.

There are only a few small pieces of this cosmopolitan species from Station unknown.

ENTALOPHORA REGULARIS (*MacGillivray*). (Pl. 29. figs. 10–14.)

Pustulopora regularis, MacGill. Descr. of new Polyzoa, pt. IV., Trans. Roy. Soc. Vict. 1882, vol. xix. p. 292, pl. 1. fig. 3 ; Busk, Zool. Chall. Exp. vol. xvii. pt. 50, p. 21, pl. 4. fig. 2.

Sections of decalcified material have been cut, showing in nearly all zoœcia thick membranous transverse walls, situated distally to the polypide, and not more than one has been found in any zoœcium. At first these walls or tabulæ are slightly curved, but later various forms are assumed, and the wall then rises up in the middle, so that sometimes a closed chamber is formed ; in others there is an opening, and then apparently the tentacles can pass through, though the aperture is not very large.

In many zoœcia the central projection of the wall is funnel-shaped, and this may be prolonged beyond the thick portion into a delicate small transparent tube (fig. 13, *tb.*). When this was first seen it was thought to be an accidental appearance, but being found in other zoœcia it is clearly normal.

When the transverse wall forms a pouting projection (fig. 12), then the tentacular sheath is attached to the lower part of the projection (fig. 12, *ts.*), and there is a similar thin membrane, like the tentacular sheath, arising from the point of junction of the thick transverse wall with the zoœcial wall, and this again is attached lower down to the tentacular sheath (see figs. 12, 14, *tb.*). There is living tissue both below and above the transverse wall, and the structure is seen to be in the main similar to what I described as the closures of *Heteropora claviformis* *, Waters, but the transverse walls and the calcareous closures are not identical, though related.

The diaphragm closing the tentacular sheath is near to the above-mentioned transverse wall (fig. 14, *dp.*), and this last is not close to the calcareous closure, the distance apart usually being about twice the diameter of the zoœcial tube. There are 12 tentacles ; but no ovaria were seen in the specimen, while there are a few young testes.

Although I do not find as thick a wall in any other species of Cyclostomata examined, yet there is a membrane ; and in *Hornera lichenoides*, Pont., from the Arctic, it is sometimes fairly thick, and there is beyond the wall a conical projection lined with large cells. In *Diastopora obelia*, Johnst., there is a transverse membrane, and the structure is somewhat similar in *Lichenopora*. Having obtained the key, we may hope shortly to understand the mechanism more thoroughly, and possibly the study of this structure may throw much light upon Palæozoic and other fossil Bryozoa in which the tabulæ are common.

This thick wall stains much more deeply than the other tissues, showing that it is not usually chitinous.

Hab. Victoria (*MacGill.*) ; Bass's Straits, 38 fath. (*Busk*). Cape Horn Expedition : Station 170, Canal Franklin, 95 metres, +7°·0 Cent. ; Station 183, " 10 milles au S.E. de la Fosse Sloggett," 816 met., +4°·9 Cent.

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* " Bryozoa, ' Expédition Antarctique Belge, 1904, p. 98, pl. 7. fig. 8.

IDMONEA MILNEANA, *d'Orbigny.*

Idmonea Milneana, d'Orb. Voyage dans l'Amér. Mérid. p. 20, pl. 9. figs. 17–21.

For synonyms see Miss Jelly's Catalogue, and add MacGill. Tert. Polyzoa of Victoria, p. 124, pl. 17. figs. 1, 2 (1895).

The specimens from Cape Horn have very long radical processes, given off from various parts of the dorsal surface; and the habit is so similar to that of *I. interjuncta,* MacGill., that at first it was taken for that species, but measurements of the zoœcial tubes (about 0·2 mm.) showed it to be *I. Milneana.* In d'Orbigny's specimen 13743, from the Falkland Islands, there is an ovicell near to a bifurcation, which does not extend over many zoœcia.

Hab. Falkland Islands, from considerable depths (*d'Orb.*); Tierra del Fuego and Patagonia, 30 fath.; Chonos Archipelago (*Darwin*); Azores, 450 fath. (*Busk*); Queensland (*Hasw.*); New South Wales; New Zealand (*Waters*); Kerguelen, 75–150 fath. (*Busk*); Queen Charlotte Islands (*Hincks*); Fiji; Mediterranean, as *I. notomale,* Busk. Cape Horn Expedition. [Smyth Channel, Long Island, 8 fath.; Punta Arenas (*Calvet*).]

Fossil. Tertiaries of New Zealand; do. of Mt. Gambier, Curdies Creek, Bairnsdale (Australia). European Tertiaries, Bartonian to Pliocene.

IDMONEA ATLANTICA, *Forbes.*

The zoœcial tubes are about 0·14 mm. internal diameter, and the series are 0·5–0·6 mm. apart.

This I have referred to in my memoir on the Antarctic Bryozoa, p. 91, and have given the distribution as Arctic, British, Mediterranean, N. Atlantic, Kerguelen, Cape of Good Hope, Tristan da Cunha, Antarctic, and Cape Horn, station unknown.

There is one small piece of *Idmonea* with rather larger zoœcia and the series further apart.

HORNERA ANTARCTICA, *Waters.*

Hornera antarctica, Waters, Expéd. Antarct. Belge, Bryozoa, p. 93, pl. 9. figs. 1 *a–l.*

There are a few small pieces of this *Hornera,* which is closely allied to *H. lichenoides.* It was found in the Antarctic at depths varying from 480–569 metres.

LICHENOPORA FIMBRIATA (*Busk*).

This species was described by Jullien as *Disporella spinulosa*, Jull., see my "Bryozoa," Expéd. Antarct. Belge, p. 96, pl. 8. fig. 20.

DISCOTUBIGERA ? LINEATA (*MacGillivray*).

Diastopora lineata, MacGill. Trans. Roy. Soc. Vict. vol. xxi. (1885) p. 96, pl. 3. fig. 1.

Liripora lineata, MacGill. Trans. Roy. Soc. Vict. vol. xxiii. (1887) p. 182.

Discotubigera lineata, Waters, Ann. Mag. Nat. Hist. ser. 5, vol. xx. p. 260, pl. 6. fig. 24 ; Journ. Linn. Soc., Zool. vol. xx. p. 284, pl. 15. fig. 5.

There is only one specimen in the Cape Horn material, and it was growing on *Aspidostoma giganteum*, Busk.

Hab. Victoria (*MacGill.*) ; New South Wales (*Waters*). Cape Horn, Station unknown.

EXPLANATION OF THE PLATES.

PLATE 28.

Fig. 1. *Microporella Hyadesi*, Jull. Showing the ovicell and the bridge below it. From the Falkland Islands, 261 *a*, Mus. d'Hist. Nat. Paris. × 25.

2. *Microporella Hyadesi*, Jull. Median pore, × 250.
3.   ,,   ,,   Operculum, × 85.
4.   ,,   ,,   Mandible, × 85.
5.   ,,   ,,   Ovicell seen from the side, and also the bridge, × 25.

6. *Cribrilina patagonica*, sp. nov. Cape Horn Exp., Station unknown. ×25.
7.   ,,   ,,   Operculum, × 85.

8. *Schizoporella patagonica*, sp. nov. Station unknown. ×25.
9.   ,,   ,,   × 85.
10.   ,,   ,,   Mandible, × 85.
11.   ,,   ,,   Operculum, × 85.

12. *Adeonella lichenoides*, M. Edw., × 25. *a*, natural size. From Station unknown, Cape Horn Exped.

13. *Smittia Lebruni*, sp. nov. Station unknown. × 25. *a*, large mandible, × 85; *b*, operculum, × 85; *c*, mandible, × 85.

14. *Membranipora falcifera* (Busk), × 25. Station unknown.
15.   ,,   ,,   Avicularium, × 85.

16. *Cellarinella dubia*, Waters. Station 4, Exp. Cape Horn.

Waters.

Linn. Soc. Journ. Zool. Vol. XXIX. Pl. 28.
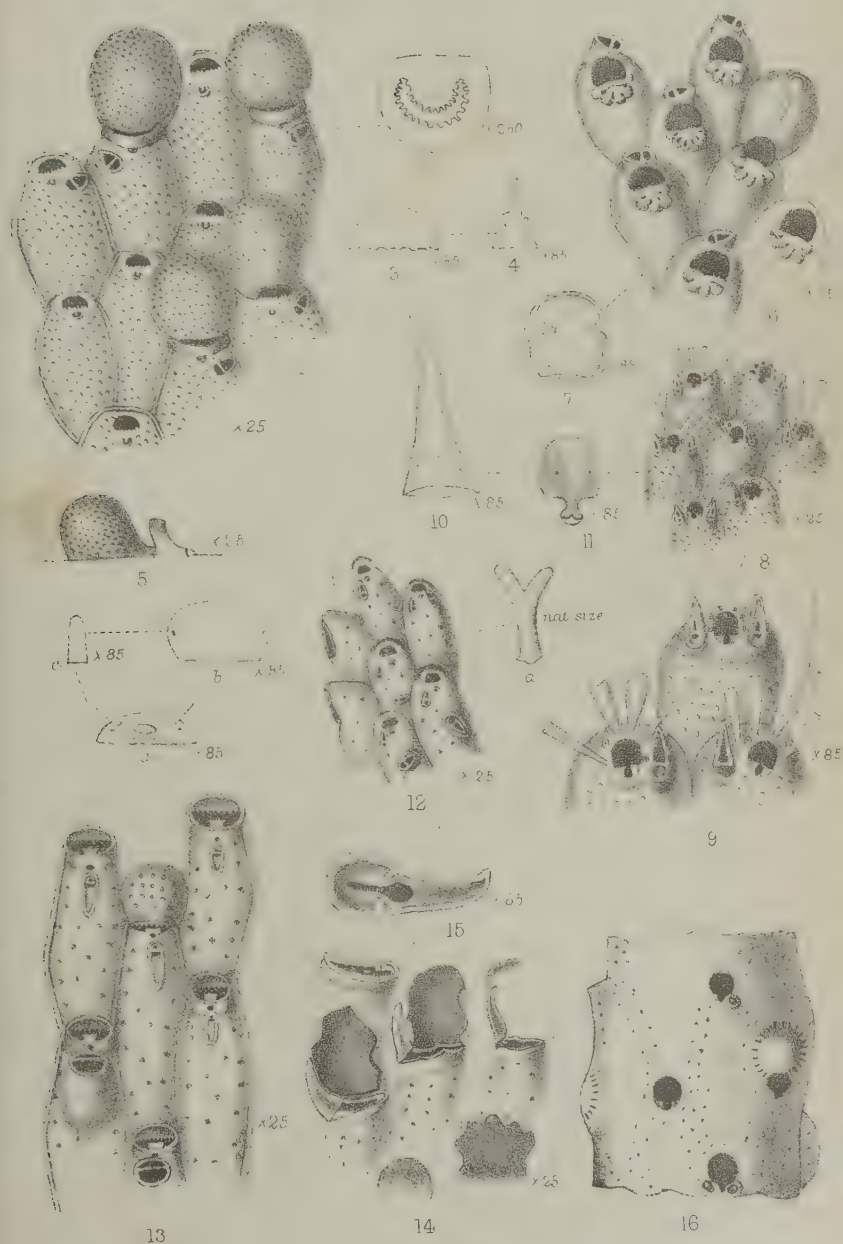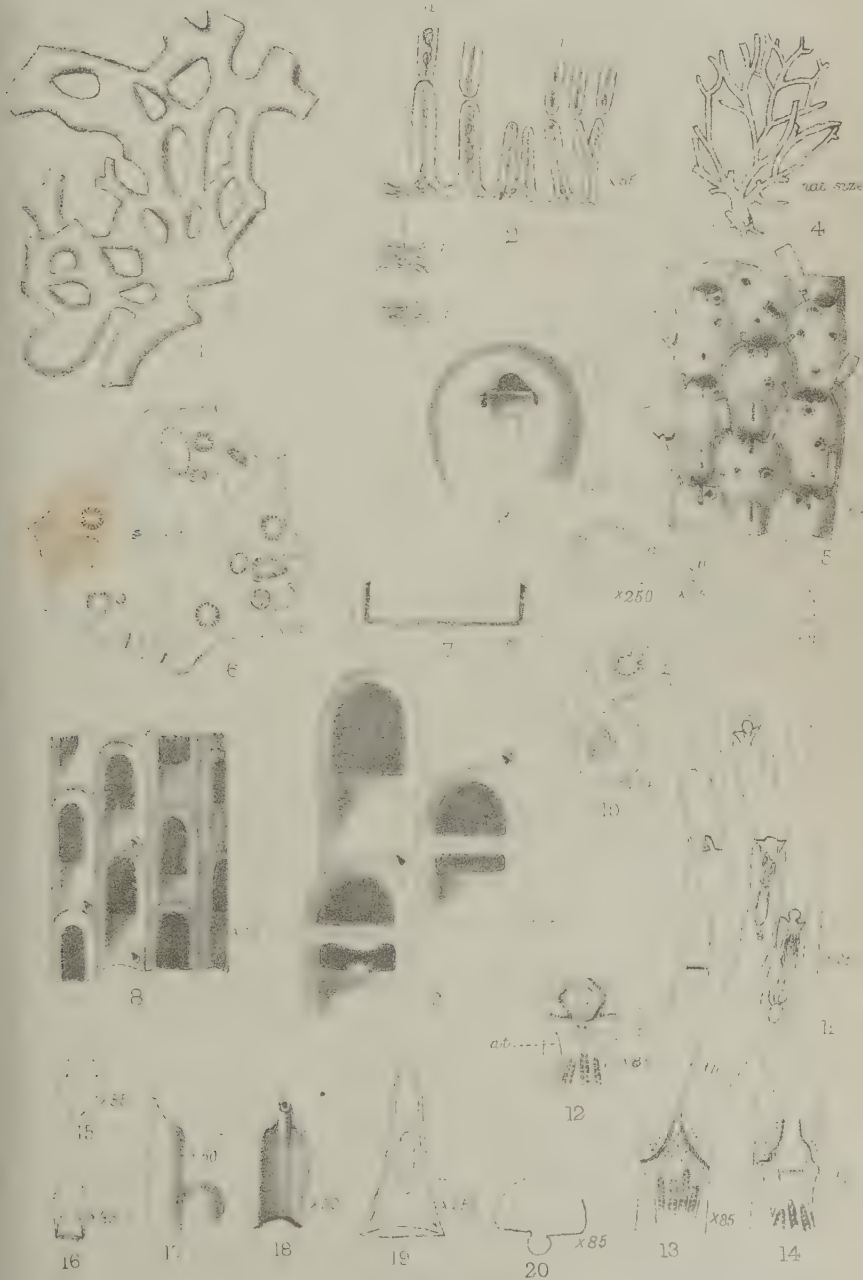
A.W. Waters del.
A.T. Hollick lith.

West, Newman imp. London.

CAPE HORN BRYOZOA.

CAPE HORN BRYOZOA.

Plate 29.

Fig. 1. *Aspidostoma giganteum*, Busk. Showing reticulate growth, half natural size. From sketch made in Paris in order to show the growth approximately. Station unknown.

2. *Aspidostoma giganteum*, Busk. *a*, distal connections; *b*, lateral connections through the rosette-plates. × 85.

3. *Aspidostoma giganteum*, Busk. Zoœcium showing the lamina below the aperture, and small lateral projections at each side. × 25.

4. *Retepora spatulifera*, sp. nov. Natural size. From Station 4.

5. ,, ,, × 25. *a*, mandible, × 250; *b*, do., × 85; *c*, operculum, × 85.

6. *Thalamoporella labiata*, Busk. Decalcified section, × 25.

7. ,, ,, Section of operculum, × 85.

8. ,, ,, × 12. From Cape Horn Exped.

9. ,, ,, Specimen in Mus. d'Hist. Nat. Paris, named and figured by d'Orbigny as *Vincularia elegans*, d'Orb., No. 13616. × 25.

10. *Entalophora regularis*, MacGill. Transverse section, showing connection through tubes divided by a disk, × 25.

11. *Entalophora regularis*, MacGill. Longitudinal decalcified section, showing thick membranous transverse walls, × 25.

12. *Entalophora regularis*, MacGill. The thick membrane projects in the middle, but is not closed below. *ts.*, tentacular sheath; *at.*, tissue attached to the tentacular sheaths and to the zoœcial wall.

13. *Entalophora regularis*, MacGill. There is a thin (*tb.*) tube arising from the transverse membrane. × 85.

14. *Entalophora regularis*, MacGill. *dp.*, diaphragm.

15. *Lagenipora lucida*, form *nitens*, MacGill. Operculum, × 85.

16. ,, ,, ,, Mandible, ×85.

17. ,, ,, End of zoœcium showing ovicell, × 50.

18. ,, ,, End of zoœcium seen from the inside, × 50.

19. *Cellepora petiolata*, sp. nov. Mandible, × 250.

20. ,, ,, Operculum, × 85.

On the Cranial Osteology of the Fishes of the Families *Osteo-glossidæ*, *Pantodontidæ*, and *Phractolæmidæ*. By W. G. RIDEWOOD, D.Sc., Lecturer on Biology at St. Mary's Hospital Medical School, London.

[Read 19th January, 1905.]

(PLATES **30–32**.)

AN extensive investigation on the structure of the skull of the lower Teleostean fishes which I began in the year 1896 has now arrived at a stage of progress that warrants the publication of certain of the results. Two papers have already appeared : one, on the skull of the Elopidæ and Albulidæ, in the ' Proceedings of the Zoological Society ' (1904, ii. pp. 35–81), and the other, on the skull of the Mormyridæ, Notopteridæ, and Hyodontidæ, in the ' Journal of the Linnean Society ' (Zoology, xxix. 1904, pp. 188–217). The present communication represents a third instalment of the results ; a fourth, dealing with the skull of the Clupeoid fishes, is rapidly approaching completion.

Seven species of fishes are considered in this paper—three species of *Osteoglossum**, and one species of each of the genera *Arapaima*, *Heterotis*, *Pantodon*, and *Phractolæmus*. These fishes are all of freshwater habit, they are all tropical, and, with the exception of *Osteoglossum Leichardti* of Queensland, all occur within ten degrees of the Equator. *Osteoglossum bicirrhosum* and *Arapaima gigas* are found only in Brazil and Guiana, *Osteoglossum formosum* in Borneo and Sumatra, and *Heterotis niloticus*, *Pantodon Buchholzi*, and *Phractolæmus Ansorgii* in Equatorial Africa.

One of the most striking and characteristic features of the skull of the Osteoglossid fishes is the occurrence of a paired lateral peg of the parasphenoid bone for articulation with the hyopalatine arch, described by Bridge in *Osteoglossum formosum*

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* The Australian species of *Osteoglossum* was described by Günther in 1864 under the name of *Scleropages*, but he afterwards withdrew the genus, considering his *Scleropages Leichardti* to be a species of *Osteoglossum*. Boulenger, however (Ann. Mag. Nat. Hist. (7) viii. 1901, pp. 514–515), has recently found that *Osteoglossum bicirrhosum* differs from *O. formosum* and *O. Leichardti* in the number of vertebræ, the position of the pelvic fins, and the number of branchiostegal rays, and he proposes to re-establish the genus *Scleropages* for the inclusion of the latter two species.

(Proc. Zool. Soc. 1895, pp. 302–310). When, during the course of the investigation, it was found that this articulation occurred in *Arapaima* and *Heterotis* and in *Osteoglossum bicirrhosum* and *Osteoglossum Leichardti*, as well as in *Osteoglossum formosum*, it became of interest to ascertain whether it was present in *Pantodon* and *Phractolæmus*, isolated genera belonging to families of their own, but usually associated with the Osteoglossidæ. As is shown in the sequel, the articulation is present in *Pantodon*, but not in *Phractolæmus*.

I have to acknowledge my indebtedness to Mr. G. A. Boulenger for offering to me facilities for the examination of the skulls of *Pantodon*, *Phractolæmus*, *Arapaima*, *Heterotis*, and *Osteoglossum bicirrhosum* in the British Museum collection, and to Prof. G. B. Howes and Prof. T. W. Bridge for the loan of skulls of *Osteoglossum Leichardti* and *Osteoglossum formosum* respectively.

OSTEOGLOSSIDÆ.

OSTEOGLOSSUM.

Figures of the top and side of the skull of *Osteoglossum formosum*, and a few words of explanation, are given by Müller and Schlegel (Temminck's Verh. Nat. Ges. Nederl. overz. bez., Zool., Leiden, 1839–44, Pisces, pl. i. figs. 2 & 3, and pp. 5 & 6). A few remarks on the skull-bones of the same species of *Osteoglossum** are included in Hyrtl's account of the skull of *Heterotis Ehrenbergi* (Denkschr. Akad. Wiss. Wien, viii. 1854, pp. 73–76). Bridge's account of the skull (*Osteoglossum formosum*, Proc. Zool. Soc. 1895, pp. 302–310), though more detailed, is incomplete, being limited to "certain features," notably the articulation between the parasphenoid and the hyopalatine arch.

OSTEOGLOSSUM LEICHARDTI.

The skull here described is one specially prepared for the purposes of this investigation from a specimen belonging to the Royal College of Science, London.

Cranium (Pl. **30**. figs. 1, 2, and 3).—The parietal bones touch one another in the median line of the head. The surface of the anterior two-thirds of each is sculptured, the posterior third lies at a lower level and is not sculptured. The frontal bones are

* The species is identified as *formosum* by Boulenger (Ann. Mag. Nat. Hist. (7) viii. 1901, p. 514).

relatively short; they do not extend over the ethmoid region, the enlarged nasals constituting the roofing-bones of this part of the cranium. The nasals are important bones, suturally united with the frontals, with the mesethmoid, and with one another, and also united by their edges with the preorbitals and premaxillæ. They cover the prefrontals completely.

The mesethmoid is a small rhombic bone of ectosteal origin. The nasal, frontal, and mesethmoid bones, and the upper portion of the squamosal are sculptured. The opisthotic is comparatively large; its ventro-lateral angle is united with a backwardly directed process of the pro-otic. The postfrontal does not present itself in a dorsal view of the skull, but is covered by the frontal, squamosal, and postorbital bones. Neither orbitosphenoid nor basisphenoid bone is present.

The lateral temporal groove is partially roofed over by a lateral growth of the squamosal. The margin of the posterior temporal fossa is bounded by the epiotic and squamosal, these bones uniting both above and below it. The vacuity passes forwards and slightly inwards, but does not end blindly in front; it curves outwards and opens laterally into the lateral temporal groove between the postfrontal and squamosal. This aperture appears at first glance to correspond with the "temporal foramen" of the Clupeoids; but it must be remembered that the latter foramen leads directly into the cranial cavity, and is bounded by the parietal and frontal bones. The subtemporal fossa, lying immediately below the squamosal portion of the articular facet for the head of the hyomandibular, is a fairly large pit, bounded by the pro-otic, exoccipital, opisthotic, and squamosal.

A rod-like process of the parasphenoid rises on each side to meet the alisphenoid, but it does not reach the postfrontal, as it does in *Osteoglossum formosum* (Bridge, *l. c.* p. 302 and pl. 22. fig. 1). From the lower part of this process of the parasphenoid there projects a lateral peg-like outgrowth which articulates with the entopterygoid and hyomandibular. A small clump of strong teeth is situated on the ventral side of the parasphenoid just behind the articulation, and these teeth, together with those of the two entopterygoids, engage with the lingual teeth borne by the median constituents of the hyobranchial skeleton. The parasphenoid extends a little more posteriorly than the basioccipital. The eye-muscle canal does not open posteriorly; there is a distinct hole behind the parasphenoidal teeth, but this

ends blindly in front. The front of the vomer bears two large teeth and a few smaller ones.

*Temporal and Preopercular Series** (Pl. **30.** figs. 4 and 5).—The body of the post-temporal is small and horizontally disposed, and its sensory canal is continued forwards into the supratemporal. It has two limbs, nearly equal in length—a superficial one to the top of the epiotic, and a deep, more rod-like one to the back of the opisthotic. The supratemporal is a curved tubular bone, lying close behind the transverse crest of the squamosal and parietal, with which bones it is in close fibrous union.

The preopercular is sculptured in its lower part, but not in its upper part, which is overlapped by the postorbital plates. The lower limb of the preopercular is not quite half as long as the upright limb, and makes with it an angle of rather less than a right angle. The interopercular lies on the inner surface of the preopercular and is not sculptured.

Circumorbital Series (fig. 4).—In addition to the nasal bone, which has already been considered in dealing with the cranium, there are six bones of the circumorbital series. They are all sculptured. The two postorbitals are very large, and the pre-orbital and suborbital are closely bound by fibrous tissue to the upper edge of the maxilla.

Maxillary Series (fig. 4).—The premaxillæ are small in size : they are not freely movable, but are closely connected by their posterior edges with the front of the mesethmoid and nasal bones. They carry four or five teeth each. The maxillæ are long bones extending nearly as far back as the mandibular articulation. Each bears a single row of 35 to 40 sharply conical teeth, which diminish in size from before backwards. Both premaxilla and maxilla are sculptured. There is no surmaxilla.

Mandibular Series (figs. 4 and 5).—The dentary is long, with a single row of about 35 teeth, diminishing in size from before backwards. The angular is distinct from the articular, and a sesamoid articular is present. The exposed parts of the dentary and articular are sculptured. The articular facet for the head of the quadrate is formed by the articular alone.

* The reasons for including the preopercular and interopercular bones in this series, and for excluding them from the opercular and branchiostegal series, are given in a former paper (Proc. Zool. Soc. 1904, ii. pp. 68 & 75). For reasons given in the same paper it is considered expedient to regard the post-temporal as a constituent of the skull.

Hyopalatine Series (fig. 5).—The hyomandibular articulates with the cranium by a single head, broad antero-posteriorly. Its anterior edge is continued down to meet the upper part of the entopterygoid, and the lateral process of the parasphenoid lies just below and behind the junction. There is here a definite articulation between the parasphenoid and the hyopalatine arch, permitting a certain amount of lateral play to the latter, but preventing any antero-posterior movement. The process of the parasphenoid is so firmly fixed between the hyomandibular above and the entopterygoid below, that it is not easy to remove the hyopalatine arch from the rest of the skull without fracturing one or other of these bones. The metapterygoid just fails to reach the articulation.

A flat lamina of the inner part of the symplectic spreads forward over the metapterygoid and quadrate. There is no separate palatine bone; the palatine cartilage is unossified, and the ectosteal palatine is indistinguishably fused with the ecto-pterygoid. The palatine cartilage is connected with the ethmoid region of the cranium by a single terminal head, but the connection is of a ligamentous, rather than of a synovial character. Crowded teeth occur on the ectopterygoid and palatine. The entopterygoid sends forward a slender process which nearly reaches the front of the palatine; it bears numerous crowded teeth over nearly the whole of its buccal surface, the largest teeth being those nearest the median plane of the head. I cannot agree with Bridge (*l. c.* p. 305) in his contention that by means of the parasphenoidal articulation of *Osteoglossum* the teeth along the mesial edges of the two entopterygoids are enabled to grip food-material as by the action of right and left jaws, working inwards and outwards. The teeth in question are certainly obliquely set, as he states, but their points are directed vertically downwards. There can be no question that these teeth act in a vertical direction, and are opposed to the lingual teeth borne upon the bone that covers the glossohyal cartilage and the basibranchials.

Opercular Series (figs. 4 and 5).—The opercular bone is large and nearly semicircular in outline. The subopercular is small and is sculptured in its posterior part only. The number of branchiostegal rays of *Osteoglossum Leichardti* is stated by Boulenger (*l. c.* p. 515) to be 15–17. In the specimen now

under consideration there are ten only, but the series is probably incomplete *.

The first seven have the form of curved thin rods, the last three are larger and broader. The first eight are connected with the outer surface of the ceratohyal, the other two with the outer surface of the epihyal.

Hyobranchial Series.—The hypohyal is single on each side, and is attached to the upper half of the anterior extremity of the ceratohyal. The anterior end of the urohyal lies between the lower halves of the anterior ends of the right and left ceratohyals. The urohyal is comparatively small, and does not extend back behind the middle of the second basibranchial. A large dentigerous bone overlies the glossohyal cartilage, the first and second basibranchial bones, and the anterior half of the third. From the mesial edge of the ventral side of the anterior end of the second hypobranchial there descends a stout process of rod-like form, almost equalling in length the hypobranchial itself. The first pharyngobranchial is cartilaginous and there is no spicular bone.

Osteoglossum bicirrhosum.

The skull examined is that belonging to a skeleton in the British Museum, labelled " 1890.2.25.60, Brazil."

The frontal bones are longer than in *Osteoglossum Leichardti*, and the nasals are shorter, while the mesethmoid is quite diminutive. The prefrontals appear to be unossified. The posterior temporal fossa does not open into the lateral temporal groove. The ascending wing of the parasphenoid enters into relation with the postfrontal, as in *Osteoglossum formosum* (Bridge, *l. c.* p. 302). The dentition, as a whole, is less robust than that of *O. Leichardti*, and the clump of teeth on the parasphenoid is smaller. The ventral surface of the anterior half of the parasphenoid is strongly grooved, whereas in *O. Leichardti* it is flat.

There is a distinct third, or supratemporal, limb to the post-temporal, whereas in *O. Leichardti* this is barely recognisable. The opening by which the sensory canal comes to the surface of the preopercular bone occurs higher up that bone in *Osteoglossum bicirrhosum* than in *O. Leichardti*. The premaxilla bears 10 or 11 teeth, and the maxilla, which is conspicuously longer and more slender than that of *O. Leichardti*, carries 64 to 68 teeth.

* In another specimen (No. 92.1.14.37) there are 13 rays.

The dentary, also, is longer and more slender, and carries 64 or 65 teeth. The sculpturing of the maxillary and mandibular bones is less obvious than in *O. Leichardti*.

The parasphenoid-hyopalatine articulation concerns the entopterygoid, not the metapterygoid. The branchiostegal rays in the specimen examined are eight on each side; but Agassiz (Spix, Pisc. Bras.), Günther (Brit. Mus. Cat. Fishes, vii. p. 378), and Boulenger (Ann. Mag. Nat. Hist. (7) viii. 1901, p. 514) put the number at ten. The third pharyngobranchial is considerably stouter than in *O. Leichardti*.

OSTEOGLOSSUM FORMOSUM.

Seeing that in *Osteoglossum Leichardti* and *O. bicirrhosum* the parasphenoidal pegs articulate with the entopterygoid, whereas Bridge described the articulation as taking place with the metapterygoid in *O. formosum*, I was particularly anxious to examine this last species, and Prof. Bridge was good enough to lend me the skull which in 1895 he described in the 'Proceedings of the Zoological Society.'

The skull is in many respects intermediate between those of *O. Leichardti* and *O. bicirrhosum*. The nasal is more sculptured than in the latter, but the size of the nasal relatively to the frontal is more like that of *O. bicirrhosum* than that of *O. Leichardti*. The prefrontal is ossified. The posterior temporal fossa does not open into the lateral temporal groove.

The cluster of teeth on the parasphenoid is smaller than in *O. bicirrhosum*, and the two posterior teeth are much larger than the other 10 or 12. The appearance of this cluster is well shown in Bridge's figs. 1, 2, and 4. The ventral surface of the front half of the parasphenoid is grooved. Teeth are present on the vomer. There are 10 or 11 teeth on each premaxilla, and about 50 on each maxilla, while each dentary carries about 52 teeth. The jaw-bones are longer than those of *O. Leichardti*, but not so long as those of *O. bicirrhosum*.

The parasphenoidal articulation is with the entopterygoid, and not the metapterygoid as described by Bridge. On returning to Prof. Bridge the skull which he was good enough to lend me for examination, I pointed this out, and received in reply an admission that he now regarded the articulation as really entopterygoidal.

The preopercular is intermediate in character between those

of *O. Leichardti* and *O. bicirrhosum*. The branchiostegal rays are 14 or 15 in number on each side : according to Müller and Schlegel (Temminck's Verh. Nat. Nederl. overz. bez., Zool., Leiden, 1839–44, Pisces, p. 7) the number is 15 ; Hyrtl (Denkschr. Akad. Wiss. Wien, viii. 1854, p. 76) says 17 ; Günther (Brit. Mus. Cat. Fish. vii. 1868, p. 378) says 15 ; Boulenger (Ann. Mag. Nat. Hist. (7) viii. 1901, p. 515) says 15–17.

HETEROTIS NILOTICUS.

Hyrtl (Denkschr. Akad. Wiss. Wien, viii. 1854, pp. 73–76, three plates) has published a side view of the skull of *Heterotis,* and a moderately good description, not sufficiently detailed, however, to be of much real service. An account of the hyobranchial skeleton is also given, and his figures of the epibranchial organ, the shape of which he compares with that of the shell of *Planorbis,* show well the peculiar features of this remarkable structure.

Views of the skull, gills, and epibranchial organ are also given by Hemprich and Ehrenberg (Symbolæ Physicæ, zootomical plates 8 and 9, 1899).

The skull described below is that of a skeleton in the British Museum. It is marked " Kartoum," but bears no register number.

Cranium (Pl. **31**. figs. 6, 7, and 8.)—The nasal bones are large and are incorporated into the cranium ; they meet one another in a median suture, and are suturally united with the frontal bones.   The mesethmoid is small, and appears on the dorsum of the cranium between the anterior ends of the nasal bones.   The frontals are large and broad ; the parietals are comparatively large and meet in a median suture.   The nasal, frontal, squamosal, and parietal bones are sculptured, but the hindermost parts of each parietal and squamosal lie at a deeper level and are not sculptured.   Shallow unsculptured depressions, each with a perforation by which the sensory canal comes to the surface of the head, occur on the nasal, frontal, parietal, and squamosal bones in the positions shown in fig. 6.   The supraoccipital is small and has a feeble crest, and the posterior part of the cranium lying beneath the supraoccipital and above the foramen magnum is cartilaginous (fig. 8).

The occipital half-vertebra comes away readily from the ex-occipitals and basioccipital, and leaves their posterior ends rough. It has a complete neural arch, but no neural spine ; it bears a

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pair of intermuscular bones, and a pair of large ribs*, which are attached to the upper ends of the clavicles. This half-vertebra is not shown in figs. 6, 7, and 8, but a separate view of it is given in fig. 11. Since both the ribs and the intermuscular bones slope backward as well as outward, they appear in the figure shorter than they really are. These ribs are shown at *a* in Hyrtl's pl. 2. fig. 1; the bones marked *b* are the ribs of the next vertebra but one, a fact which one would not gather from an examination of his figure, nor from his description of them (p. 88) as " das erste Rippenpaar."

The opisthotic is fairly large, and extends forward to meet the pro-otic, but above the junction of the opisthotic with the pro-otic there is no subtemporal fossa. The posterior temporal groove is not well marked, although in *Arapaima* and *Osteoglossum* there is a completely roofed posterior temporal fossa ; the lateral temporal fossa is roofed over by the squamosal bone to a greater extent than in *Osteoglossum*. The side view of the skull shows a large foramen between the exoccipital and basioccipital, bounded mainly by the former bone; it is apparently the vagus foramen, much larger than usual. The postfrontal is fairly large ; the prefrontal is of moderate size. These bones are not sculptured, being covered by bones of the circumorbital series.

The cranial cavity extends forward through, and in front of, the orbital region, so that the membranous interorbital septum is reduced to a small tract between the alisphenoids and the parasphenoid. The two alisphenoids meet along their ventral edges in a median suture, and the hinder end of this suture meets an upwardly directed process of the parasphenoid. The orbitosphenoid is a broad, imperfectly ossified sheet of cartilage, U-shaped in section. It rests upon the parasphenoid, and is united with the prefrontals anteriorly, with the alisphenoids posteriorly, and with the frontals above.

There appears to be no basisphenoid. The eye-muscle canal does not open posteriorly. Neither the vomer nor the parasphenoid bears teeth. The parasphenoid divides posteriorly into

* Although a pair of strong intermuscular bones pass from the occipital half-vertebra to the upper ends of the clavicles in *Chanos*, they are not homologous with the bones now under consideration, which arise lower down the side of the half-centrum and are in serial order with the ribs. The resemblance in the two cases is curious, but it is not one of homology.

two slender points which lie closely bound to the right and left
sides of the anterior half of the basioccipital. Just in front of
the pro-otic region a pair of strong oblique processes extend
from the parasphenoid outward, forward, and downward, for
articulation with the entopterygoid.

Temporal and Preopercular Series (figs. 9 and 10).—The post-
temporal has an upper limb the anterior extremity of which
overlies the epiotic, and a deep, rod-like limb attached by liga-
ment to the posteriorly directed process of the opisthotic. The
horizontal sensory canal lies towards the ventro-external part of
the body of the post-temporal bone, and the bony tube surround-
ing the canal is continued forward towards the supratemporal,
but fails to reach it. The supratemporal is rather small, and is
partly wedged in beneath the postero-lateral margin of the
parietal. It is not a sculptured bone.

The lower part of the preopercular is sculptured. The lower
limb is nearly as long as the upright portion, and makes with it
an angle of rather less than a right angle. The interopercular
is a thin flake of bone, of large size, lying on the inner surface
of the lower part of the preopercular.

Circumorbital Series (fig. 9).—In addition to the nasal bone,
previously mentioned, there are five bones of this series. The
preorbital bone has a prominent ridge running upwards along its
inner surface. The largest of the series is the postorbital, the
anterior edge of which bone is considerably thickened. They
are all sculptured.

Maxillary Series (fig. 9).—The mouth, when viewed from the
front, is curiously square in shape, and the upper side of the
square is formed by the premaxillæ. The two premaxillæ are
separated by the narrow vomer, so that the middle part of the
upper jaw is toothless. Each premaxilla bears about thirteen
teeth. The number of teeth in the maxilla is about fourteen,
and these, like those of the premaxilla, are long, blunt, and
curved at the tips. The maxilla, when isolated, is seen to be
bent at its middle into a right angle. The horizontal part lies
over the premaxilla and is toothless ; it nearly reaches the
vomer, but does not enter into definite relation with it and has
no articular head. There is no surmaxilla.

Mandibular Series (figs. 9 and 10).—The dentary rises high,
and the coronoid process is set well forward. The teeth are
similar to those of the premaxilla, and are about twenty-two

in number. The articular does not rise very high, and forms no part of the coronoid process. The endosteal articular does not appear to be readily separable from the ectosteal articular; there is a small sesamoid articular. The angular bone is distinct from the articular, and forms the lower part of the articular facet for the head of the quadrate.

Hyopalatine Series (fig. 10).—The hyomandibular articulates with the cranium by two barely separated heads, the anterior of which is smaller than the other and rises higher. The opercular head is stout. The hyomandibular enters into sutural relation with the preopercular as well as the metapterygoid along its ventral edge; it sends a slender process forward to meet the entopterygoid. As in *Osteoglossum*, a lateral process of the parasphenoid articulates with the back of the entopterygoid just beneath this process of the hyomandibular. The part of the entopterygoid that lies below and in front of the articulation carries an oval patch of crowded teeth, straight and rather blunt. It is worthy of note that Valenciennes alludes incidentally to this articulation between the hyopalatine arch and the parasphenoid (Hist. Nat. Poiss. xix. 1846, p. 471).

The ectopterygoid is slightly curved, and is not continued down the anterior edge of the quadrate. The relations of the palatine are rather strange, for the entopterygoid and ectopterygoid both extend to the anterior end of the hyopalatine arch, while between their anterior portions, and confluent with them, lies an extremely delicate membrane-bone, apparently to be identified as the palatine, bearing on its upper surface, at some distance from the front, the conical endosteal palatine. The palatine and ectopterygoid are edentulous.

Opercular Series (figs. 9 and 10).—The opercular bone is of average size and shape. The subopercular is wanting on both sides in the specimen under observation, but it is important to note that Valenciennes (Hist. Nat. Poiss. xix. 1846, p. 470) has described a small subopercular in the following terms:—" Le sous-opercule est représenté ici par une toute petite pièce osseuse, mince comme une écaille et située dans le petit espace angulaire que laissent entre eux l'opercule et le préopercule. J'insiste sur la petitesse de cet os, parce qu'il est très-facile de l'enlever et de le perdre dans l'épaisseur du bord membraneux de l'opercule en préparant le squelette du poisson, et j'avertis qu'il faut l'avoir vu sur le squelette pour le retrouver sur le poisson desséché."

The branchiostegal rays are eight in number on each side. Of

these, four are on the ceratohyal, one lies on the junction between the epihyal and the ceratohyal, two on the lower edge of the epihyal, and the last one about halfway up the outer face of the epihyal. The first five are slender rods, the other three are lamellate. The last of all, which is the largest, tends to remain on the inner surface of the interopercular when the head is dissected prior to the maceration of the bones. Rüppell (Beschr. neu. Nil-Fische, 1829, p. 11) puts the number of branchiostegal rays of *Heterotis* as 7, as also do Hyrtl (Denkschr. Akad. Wiss. Wien, viii. 1854, p. 75) and Boulenger (Ann. Mag. Nat. Hist. (7) viii. 1901, p. 515); Valenciennes (*l. c.* p. 471) and Günther (Brit. Mus. Cat. Fishes, vii. 1868, p. 380) say 8. Eight are shown in pl. 8 (zootom.), fig. 2 of Hemprich and Ehrenberg (Symbolæ Physicæ, 1899).

Hyobranchial Series. — The hyobranchial skeleton of the specimen examined is incomplete. The urohyal is short and stout and lies between the strongly-developed processes that project downward from the anterior ends of the second hypobranchials. There is a small upper hypohyal, but no lower. The basibranchial teeth, which are not quite so large as those of the entopterygoid, are arranged in a patch, about as broad as long, set on the middle part of the length of the membrane-bone that covers the hinder part of the glossohyal, the whole of the first and second basibranchials and the anterior three-fourths of the third. The epibranchial organ is borne by the fourth and fifth arches.

The glossohyal, the first basibranchial, and the first pharyngobranchials appear to be cartilaginous, and there are no spicular bones. According to Cope (Trans. Amer. Phil. Soc. n. s. xiv. 1871, p. 455) there are but two superior pharyngeals in *Heterotis*, whereas in *Osteoglossum* there are three. Seeing that in both *Osteoglossum* and *Heterotis* the first pharyngobranchial is unossified, the only explanation of the statement lies, I think, in the fact that Cope, in examining *Osteoglossum*, mistook for a pharyngobranchial the patch of coalesced teeth that lies behind the third pharyngobranchial, and immediately beneath that cartilaginous rod which represents the fourth pharyngobranchial. The dentigerous plate in question is wanting in *Heterotis*.

ARAPAIMA GIGAS.

The only published figures and description of the skull of *Arapaima* are those of Agassiz (Spix, Selecta Genera et Species Pisc. Bras. 1829, pl. B of the Anatomical Plates, and pp. 33–40).

The bones are numbered and are referred to in detail in the text.
A copy of the uppermost figure of the plate was republished in
1844 without the numbers (Agassiz, Monog. Poiss. Foss. Vieux
Grès Rouge, 1844–45, pl. F : see also pp. 107–109 of the text).
The relations of the sculptured to the non-sculptured parts of
the head are well shown in the figures given by Valenciennes
(Hist. Nat. Poiss. xix. 1846, pls. 579–582).

Two skulls of *Arapaima* were available for study—a small
incomplete skull measuring 7 inches in length, and a full-
sized skull, about 16 inches long, forming part of an articu-
lated skeleton exhibited in the British Museum. The details of
the cranium, hyopalatine arch, and mandible were made out from
the small specimen, and figs. 12, 13, 14, and 16 were drawn from
this ; fig. 15, showing the superficial bones, was drawn from the
larger specimen.

Cranium (Pl. 32. figs. 12, 13, and 14).—The parietals are large,
and meet one another in the median line along their whole
length. The squamosals appear rather small as compared with
the parietals. The nasals are of considerable size and are
incorporated into the cranium ; they meet one another in a median
suture, and are suturally united with the anterior edges of the
frontals. The nasal, frontal, parietal, and squamosal bones are
sculptured on their upper surface, but each has a shallow
depression devoid of sculpturing, at the bottom of which is a
perforation where the tubes of the sensory canal-system come to
the surface. A median depression of a similar nature occurs
in the postero-mesial parts of the parietal bones, just in front of
the supraoccipital. The posterior, deep-lying part of the parietal
is relatively much smaller than in *Osteoglossum*, and forms but a
small semicircular lamina overlying the base of the epiotic promi-
nence. Neither the prefrontal nor the postfrontal comes to the
surface of the head, and neither is sculptured.

There is a backwardly directed supraoccipital crest of small
size. The vagus foramen in the middle of the side of the
exoccipital is large, and in the part of the exoccipital bone which
forms the side of the foramen magnum there are three foramina,
as in *Osteoglossum*. The opisthotic is of moderate size ; it is
united with the epiotic, exoccipital, and squamosal, and with a
backward prolongation of the pro-otic. A lateral depression
occurs in the upper part of the pro-otic bone ; the subtemporal
fossa is ill-defined and shallow. The posterior temporal fossa is

completely roofed; its aperture is triangular in the small specimen, but rounded in the large one; it is bounded by the epiotic, opisthotic, and squamosal. Its anterior blind end is limited by the supraoccipital, parietal, and squamosal bones.

The occipital half-centrum presents a shallow concavity behind, and is readily separable from the basioccipital and exoccipital bones. The vertebral centrum behind this may also be regarded as a constituent of the cranium, since its lower portion is continued forward into two parallel processes, right and left, which are rigidly united by long jagged sutures with the back of the parasphenoid. The parasphenoid bears a long patch of crowded small teeth, and from its lateral edges there project, as in *Osteoglossum* and *Heterotis*, a pair of strong processes which enter into definite articulation with the entopterygoids. Each lateral process of the parasphenoid projects slightly forward, and is covered by synovial cartilage on its anterior edge. The vomer is a flat bone, bearing crowded small teeth similar to those of the parasphenoid. The mesethmoid is almost entirely cartilaginous; there is a small median endosteal ossification lying between the nasals above and the vomer below, but it does not present itself on the surface of the skull.

The orbitosphenoid is a paired bone of small vertical extent, in contact with the frontals above and the parasphenoid below. The orbitosphenoids reach the prefrontals in the large specimen, but not in the smaller; they are apparently separated from the alisphenoids behind. Unfortunately the alisphenoids are missing from both specimens, as also is the basisphenoid bone.

Temporal and Preopercular Series (fig. 15).—The post-temporal consists of a curved flake of bone continued forward into a point which rests over the epiotic pominence. The sensory canal traverses its lateral edge horizontally; the deep or opisthotic limb is well developed and is almost as long as the epiotic limb. The bone is not sculptured. In the larger specimen, owing to the forward spreading of the bone diminishing the space between the epiotic and opisthotic limbs, these limbs appear shorter than in the smaller specimen.

The horizontal limb of the preopercular is about as long as the upright limb, and makes an angle of 90 degrees with it. The strong development of the horizontal limb of the preopercular, taken in conjunction with the slope of the hyomandibular, points either to a reduction in the length of the gape, or to an increase

in the length of the postorbital portion of the head ; the latter is the more probable supposition. The interopercular is a large, flat lamina of bone ; it lies hidden by the lower part of the pre-opercular and is not sculptured.

The supratemporal differs considerably in shape and relative size in the two skulls. In the smaller skull it is a small bone which fits into the depression between the posterior ends of the parietal and squamosal. Only a small portion of it is superficial and sculptured, and the tubular portion that carries the sensory canal is continued backward to about the same transverse level as the tip of the epiotic prominence. In the larger specimen the supratemporal is of fair size ; it projects downward and outward from the parietal and squamosal so as nearly to reach the upper edge of the opercular bone, and its anterior edge unites by a serrated suture with the posterior edge of the upper of the large postorbital plates.

Circumorbital Series (fig. 15).—The nasal bones have already been mentioned in dealing with the cranium. The orbital ring is complete and consists of five bones. The preorbital forms the anterior half of the upper border of the orbit, and the uppermost of the postorbitals the posterior half ; the other two postorbitals are very large cheek-plates ; there is one suborbital. These bones are all sculptured except in certain elliptical areas, within each of which is an opening for the sensory canal.

Maxillary Series (fig. 15).—The gape is bounded above by both premaxilla and maxilla, the former bearing 16 or 18 teeth and the latter from 30 to 35 teeth, arranged in a single row. The teeth are uniform in size, and are rather cylindrical in shape, somewhat laterally compressed, with very slight curvature and with bluntly conical tips. The posterior part of the premaxilla is overlapped by the nasal in such a manner as to suggest that there is no freedom of movement between these bones. The edentulous portion of the maxilla that lies along the postero-ventral surface of the premaxilla is long and tapering, and extends as far as the median plane of the head. The extremities of the two maxillæ thus meet one another behind the premaxillary symphysis, but they do not themselves unite in any definite manner. The exposed part of the premaxilla is sculptured, but the maxilla exhibits no sculpturing, or just a little near the roots of the teeth. There is no surmaxilla.

Mandibular Series (figs. 15 and 16).—The coronoid process

has the form of a thin vertical plate with concave upper border ; it is constituted mainly by the dentary, but the ectosteal articular forms the posterior extremity.   The endosteal articular and the ectosteal articular are distinct and separate readily.   The articular surface for the quadrate is formed mainly by the endosteal articular, but partly also by the angular, which is a separate bone.   There is no sesamoid articular.   The ventro-lateral surfaces of the angular, ectosteal articular, and dentary are sculptured.

The dentary bears a single row of about 30 teeth similar in form and size to those of the maxilla.   The bone is very complete on the inner or lingual side of Meckel's cartilage, and bears one, two, or three elliptical patches of small teeth in the position shown in fig. 16 at *s*.   These teeth were noticed by Valenciennes, who wrote concerning them :—" Au côté interne de chaque branche de la mandibule je vois, sur une assez large plaque triangulaire, un groupe de fines scabrosités ou de petites dents, semblables à celles des palatins " (Hist. Nat. Poiss. xix. 1846, p. 446). Although the bony lamina that bears the teeth occupies the position of the splenial bone, it is not a distinct plate of bone as might be concluded from the remark of Owen (Anat. of Vert. i. p. 123)—" The *Sudis*, fig. 88 *, the *Polypterus*, and *Amia*, have the splint-like plate along the inner surface of the ramus, called ' splenial '; it supports teeth and developes a coronoid process." The passage continues :—" In both *Sudis* and *Lepidosteus* there is superadded a small bony piece, *ib.* 29 *a*, answering to the sur-angular in Reptiles."   This bone, marked 29 *a*, is, I believe, merely the endosteal articular displaced.

Hyopalatine Series (fig. 16).—The head by which the hyo-mandibular articulates with the cranium is indistinctly divided into a small front head and a large hinder one, broad antero-posteriorly.   The head that articulates with the opercular bone is long drawn out, and on the external face of the hyomandibular there is a short projection that engages with the anterior edge of the upper part of the preopercular.   The axis of the hyomandi-bular slopes more forward than downward.   The metapterygoid is of average size, but only a small portion of it is visible in the buccal aspect of the hyopalatine arch.   The symplectic is large and of curious shape, since it throws out jagged-edged laminæ

* Fig. 88 represents the disarticulated mandible of *Arapaima gigas.*

towards the hyomandibular, metapterygoid, quadrate, and pre-
opercular.   The thickened axis, however, can be recognized, and
this makes an angle of about 50 degrees with the horizontal
plane.

Projecting from the back of the quadrate is a considerable
lamina of bone (apparently membrane-bone) which flanks the
outer surface of the lower part of the symplectic and lies just
above the horizontal limb of the preopercular.   The ectoptergoid
is not bent, and is indistinguishably united with the palatine.
In this feature, and in the absence of any endosteal part of the
palatine, *Arapaima* resembles *Osteoglossum*.   The buccal surfaces
of the pterygoid and palatine bones are almost completely covered
with densely crowded small teeth.   The lateral process of the
parasphenoid, already referred to, fits into an elliptical foramen
bounded above and behind by the hyomandibular, below by the
hyomandibular and metaptergoid, and in front by the entoptery-
goid.   The synovial articulation is with the entopterygoid.

Opercular Series (fig. 15).—The opercular bone is of average
proportions ; it is nearly semicircular in outline, and is sculptured
over the whole of its outer surface except near the upper and
anterior edges.   The subopercular is small, triangular, and not
sculptured.   There are ten or eleven branchiostegal rays, of
which five or six are attached to the ceratohyal, and the remainder
to the epihyal.   They constitute an evenly graduated series ; the
front ones have the form of slender curved rods, the hinder
ones are larger, and slightly expanded and lamellate.   Agassiz
(Spix, Pisc. Bras. 1829, Anat. Plate B, fig. 5) shows ten rays;
Valenciennes (Hist. Nat. Poiss. xix. 1846, p. 438), Günther
(Brit. Mus. Cat. Fishes, vii. 1868, p. 376), and Boulenger (Ann.
Mag. Nat. Hist. [7] viii. 1901, p. 515) are agreed in putting the
number at sixteen.

Hyobranchial Series.—In neither of the specimens available
is the hyobranchial skeleton complete.   The interhyal is ossified.
There is a single hypohyal on each side, and this is probably the
equivalent of the lower of the two that are present in so many
other Teleostean fishes.   The first, second, and third basi-
branchials are overlaid by a readily removable dentigerous plate
of the form of a greatly elongated ellipse, the teeth of which are
densely crowded and similar to those of the parasphenoid and
pterygoid bones.   Behind this is a small circular dentigerous
bone of similar character.

SUMMARY AND COMMENTS ON THE SKULL IN THE
FAMILY OSTEOGLOSSIDÆ.

A review of the craniological characters of the three genera *Osteoglossum* (with *Scleropages*), *Heterotis*, and *Arapaima* shows that they constitute a perfectly natural group. In shape and general appearance the skulls vary considerably, but in the more fundamental and essential features they are similarly constructed.

In all three, the superficial parts of the bones are sculptured. The parietal bones meet in the median line, and, as in the widely remote genus *Erythrinus*, the deeper-lying, muscle-covered hinder portion of each is not sculptured. The frontal bones are relatively short and broad in *Osteoglossum* and *Heterotis*, but in *Arapaima*, with its elongated head, their proportions are more normal. The nasal bones are large; they meet one another by a median suture, and they are suturally united with the anterior ends of the frontal bones.

The mesethmoid is small in all three genera. The opisthotic is of fair size and touches the pro-otic. A subtemporal fossa similar to that of the Elopidæ and Albulidæ is found beneath the squamosal portion of the articular surface for the head of the hyomandibular in *Osteoglossum*; in *Arapaima* the subtemporal fossa is wide and shallow, in *Heterotis* it is wanting. The basisphenoid is wanting in all three; the orbitosphenoid is a paired bone in *Arapaima*, in *Heterotis* it is an imperfectly ossified trough-like cartilage, in *Osteoglosssum* it is wanting. The occipital half-centrum comes away readily from the basioccipital and exoccipital bones, leaving their posterior ends rough, in *Heterotis* and *Arapaima*, but not in *Osteoglossum*; in *Arapaima* the centrum behind the occipital half-centrum sends forward a pair of processes which unite with the hinder part of the parasphenoid.

The posterior temporal groove is completely roofed over in *Arapaima* and *Osteoglossum*, but not in *Heterotis*; indeed, in *Heterotis* the groove is barely recognisable. In all three genera the parasphenoid bears on each side a stout peg which articulates with the entopterygoid. In *Osteoglossum Leichardti* the parasphenoid has an ascending process which reaches the alisphenoid, and in *Osteoglossum bicirrhosum* and *Osteoglossum formosum* the corresponding process reaches the postfrontal. The parasphenoid and vomer bear teeth in *Osteoglossum* and

Arapaima, but not in *Heterotis*; the eye-muscle canal does not open posteriorly.

In all three the post-temporal has well-developed epiotic and opisthotic limbs; the orbit is surrounded by five or six bones, of which the postorbitals are the largest. The gape is bounded above by the premaxilla and maxilla; teeth are borne by the premaxilla, maxilla, and dentary; there is no surmaxilla. The angular bone is distinct from the articular; it takes part in the formation of the articular facet for the head of the quadrate in *Arapaima* and *Heterotis*, but not in *Osteoglossum*. The endosteal articular is separable from the ectosteal articular in *Arapaima*, but not in *Osteoglossum* and *Heterotis*. A sesamoid articular is present in *Osteoglossum*, and a small one in *Heterotis*, but it is apparently wanting in *Arapaima*. The symplectic exhibits a tendency to spread over the adjacent bones in *Arapaima* and *Osteoglossum*, but the tendency is less apparent in *Heterotis*. In *Heterotis* there is a distinct palatine bone, but in *Osteoglossum* and *Arapaima* the palatine is not separate from the ectopterygoid. Teeth are borne by the entopterygoid in *Heterotis*, and by the entopterygoid and the combined palatine and ectopterygoid in *Osteoglossum* and *Arapaima*.

The subopercular is small in *Osteoglossum* and *Arapaima*, and very small in *Heterotis*. The branchiostegal rays number 8 on each side in *Heterotis*, 10 or 11 in *Arapaima*, 8 in *Osteoglossum bicirrhosum* (Boulenger, Ann. Mag. Nat. Hist. viii. 1901, p. 514, says 10), 10–13 in *Osteoglossum Leichardti* (Boulenger says 15–17), and 14 or 15 in *Osteoglossum formosum* (Boulenger says 15–17).

The hypohyal is single on each side. A large dentigerous lingual bone is present in *Osteoglossum* and *Arapaima*; in *Heterotis* it is only of moderate size. In *Osteoglossum* and *Heterotis* there is a downwardly directed process of the mesial end of the second hypobranchial, as in Mormyroid fishes; in both of these forms the glossohyal cartilage is unossified, and in *Heterotis* the first basibranchial also, a fact to which Cope attaches some importance (Trans. Amer. Phil. Soc. n. s. xiv. 1871, p. 455). The first pharyngobranchial is unossified and the spicular bone is absent. Cope (*l. c.*) states that the " superior pharyngeals " are three in number on each side in *Osteoglossum*, and two in *Heterotis*; the branchial skeletons of the specimens at my disposal are not sufficiently perfect to enable me to

traverse this statement, but I suspect that the "superior pharyngeal" bone stated to be present in *Osteoglossum* and not in *Heterotis* is the dentigerous plate that underlies the cartilaginous fourth pharyngobranchial.

The deductions that one draws from the above summary are that, so far as craniological characters indicate, the three genera are closely allied, that *Arapaima* is the most primitive of the three, and that there is a closer affinity between *Osteoglossum* and *Arapaima* than between *Heterotis* and either of these forms. It would be of great interest to ascertain whether such of the above characters as are common to *Arapaima*, *Osteoglossum*, and *Heterotis*, more particularly the entopterygo-parasphenoidal articulation, are possessed by the skulls of the extinct *Dapedoglossus* of the freshwater Eocene of Wyoming, and *Brychætus* of the marine Eocene (London Clay) of Sheppey, which genera are included in the family Osteoglossidæ. I have made an inspection of the remains of these fishes in the Geological Department of the British Museum, only to find that the parts most interesting in the present connection are either broken away or are concealed by matrix.

TAXONOMIC POSITION OF THE OSTEOGLOSSIDÆ.

Valenciennes (Hist. Nat. Poiss. vol. xix. 1846) placed *Osteoglossum* with *Hyodon*, following immediately after the Mormyroids, which he said they resembled in the structure of their alimentary canal (p. 287). *Arapaima* and *Heterotis* he discussed in consecutive chapters, and the former he regarded as closely allied to *Amia* (p. 439). Johannes Müller ("Bau und Grenzen der Ganoiden," Abhandl. Akad. Wiss. Berl. 1844, p. 190) placed the three genera *Arapaima*, *Osteoglossum*, and *Heterotis* together at the end of his " Clupeidæ," a very large family including not only those fishes which we are now accustomed to regard as " Clupeoid," but also such forms as *Notopterus*, *Amia*, *Alepocephalus*, *Elops*, and *Stomias*.

Günther (Brit. Mus. Cat. Fishes, vii. 1868, p. 377) founded a special family, the Osteoglossidæ, to include the genera *Osteoglossum*, *Arapaima*, and *Heterotis*, and the family has been adopted without alteration in all subsequent schemes of classification, except an admittedly artificial scheme of Cope's (Trans. Amer. Phil. Soc. n. s. xiv. 1871, p. 455), in which the Heterotidæ are associated with the Galaxiidæ, and separated from the

Osteoglossidæ, because of certain characters of the branchial skeleton.

As regards the relations considered by different writers to exist between the Osteoglossidæ and other families of Teleostean fishes, one is not justified in all cases in concluding that the families which are placed nearest to the Osteoglossidæ are regarded by the author as the families most nearly allied to it, for the necessity of treating families in linear series when writing about them tends to obscure many natural relationships of which the author is fully cognisant. It may be noted, however, that the family Osteoglossidæ is placed by Günther (Study of Fishes, 1880) between the Clupeidæ on the one hand and the Pantodontidæ, Hyodontidæ, Gonorhynchidæ, Haplochitinidæ, Percopsidæ, and Salmonidæ on the other. Gill (Smithson. Miscell. Coll. no 247, 1872, p. 15) gives the following sequence of families :—Characinidæ, Percopsidæ, Haplochitonidæ, Galaxiidæ, Osteoglossidæ, Notopteridæ, Halosauridæ, and Chauliodontidæ ; and Boulenger (Ann. Mag. Nat. Hist. (7) xiii. 1904, p. 164) the sequence :— Elopidæ, Albulidæ, Mormyridæ, Hyodontidæ, Notopteridæ, Osteoglossidæ, Pantodontidæ, Ctenothrissidæ, Phractolæmidæ, Saurodontidæ, Chirocentridæ, Clupeidæ. Smith Woodward (Brit. Mus. Cat. Foss. Fishes, iv. 1901, p. vii) states that the Osteoglossidæ are closely related to the Albulidæ.

The suborder Malacopterygii as restricted by Boulenger (*l. c.* pp. 163–165) consists of a natural assemblage of twenty-one families, beginning with those extinct families that lie on the border-line between the Ganoids and Teleosteans, and ending with specialised families like the Alepocephalidæ, Stomiatidæ, Gonorhynchidæ, and Cromeriidæ. Looking through this list, I should be disposed to associate the Osteoglossidæ with the Pantodontidæ for reasons given on p. 276, and to regard the next nearest family to be the Albulidæ. The conclusion is arrived at by a consideration of the craniological features mainly, but the characters of the other parts of the skeleton and of the soft parts of the body, so far as they are known to me, do not militate against the suggestion that the Osteoglossidæ and Albulidæ have descended from a common stock.

PANTODONTIDÆ.

PANTODON BUCHHOLZI.

The small fish known under this name is remarkable for the disproportionately large size of the fins, the shortness of the snout, the large size of the gape, the profusion of teeth, and the reduction of the opercular skeleton.   It was first described in 1876 by Peters (Monatsber. Akad. Wiss. Berl. 1876 (1877), pp. 195–200, one plate), who obtained his specimens from Victoria River, in the Cameroons ; other specimens have since been obtained from the Congo and Niger.   Although the general aspect of the fish resembles that of a Cyprinodont, it is generally admitted (Peters, *l. c.* pp. 198 and 200 ; Günther, ' Study of Fishes,' 1880, p. 653 ; Boulenger, ' Poissons du Bassin du Congo,' 1901, p. 120) that its nearest allies are to found in the Osteoglossidæ.   Several of the features of the skull of *Pantodon* have already been recorded in the three works above named.

The skull examined is that belonging to a skeleton in the British Museum, labelled " 80.11.24.12, Old Calabar."

The top of the skull is broad and flat, and is divided into four nearly equal parts by the sagittal and parieto-frontal sutures. The parietal bones are large and meet one another in an extensive median suture ; the frontal bones are broad, the length of each being not greater than its breadth.   The nasals are comparatively large ; they are slightly convex above, and are united by suture with the anterior edges of the frontal bones ; they do not meet one another in the median line, but are separated by the small mesethmoid.   The right and left pre-maxillæ are fused into a single bone and the suture is obliterated ; the bone bears a row of about fourteen small, pointed teeth, and is immovably united with the anterior edges of the nasal bones and mesethmoid.   The premaxilla lies in a broad depression in the front edge of the roof of the cranium, with the teeth pointing directly forward ; the anterior ends of the maxillary and dentary bones extend in advance of the premaxilla.

None of the bones are sculptured.   The prefrontals do not appear on the upper surface of the cranium ; the vomer is large, and at its broad front end is a row of teeth, somewhat larger than those of the premaxilla, disposed in the form of a widely-opened **V**.   Beneath that part of the parasphenoid which lies

below the pro-otic bones is a rhomboidal patch of teeth, which terminates anteriorly in a sharp point, and posteriorly in a blunt point. The teeth increase in size from before backward, and the teeth which occur at the hind end of the series are the largest which the fish possesses. On each side of this patch of teeth the parasphenoid is produced into a stout peg, which slopes slightly forward and downward, and articulates with the entopterygoid in the same manner as in the Osteoglossidæ. There are no wings of the parasphenoid ascending towards the postfrontal and alisphenoid; the eye-muscle canal does not open posteriorly.

On each side of the hinder part of the base of the cranium is an inflated bulla of very thin bone, through which may be seen a large otolith. The bulla is formed by the pro-otic, basioccipital, and exoccipital bones. A subtemporal depression, having more the form of a groove running antero-posteriorly than of a fossa, is situated above the level of this bulla, and below the posterior part of the articular facet for the reception of the head of the hyomandibular. There is no auditory fenestra, and there are no diverticula of the swim-bladder contained within the skull. A half-centrum is fused with the exoccipital and basioccipital bones, and the suture between it and the exoccipitals remains visible. The anterior vertebræ are normal, and there are no Weberian ossicles. The posterior temporal depression is not roofed over. A separate opisthotic seems to be wanting. Owing to the great breadth of the orbital region of the cranium, the two alisphenoids are set at a considerable distance apart, and the orbitosphenoid has the form of a widely open U, the right and left parts of which are nearly severed. There is no basisphenoid.

The preopercular is a bone of normal size ; it has a short horizontal limb, the extremity of which nearly touches the back of the mandible. There is no interopercular. The circumorbital bones are missing from the skull under consideration ; but it may be noted that Peters has figured two large postorbital plates, which extend nearly to the edge of the preopercular, and Boulenger writes (*l. c.* p. 120) : " La joue est cuirassée par deux grands sous-orbitaires."

The maxilla is long ; its anterior extremity projects in advance of the premaxilla, its posterior end is close behind the level of the quadrate-mandibular articulation. The lower edge of the maxilla is toothed from end to end, the teeth being arranged in

two closely approximated rows : the teeth are pointed and exhibit a very slight curvature ; they are larger than those of the premaxilla.   The front part of the maxilla is rigidly fixed to the outer side of the palatine ; there is an important articulation between the maxilla and the under side of the prefrontal, and a slight articulation between the anterior extremities of the maxillary and nasal bones.   There is no surmaxilla.

The mandibular ramus is long and slender ; the coronoid process is situated very far back, and the upper edge of the dentary is toothed from the symphysis to the base of this process. The teeth are set in two closely-set rows. like those of the maxilla, except that the largest teeth are in the outer row, whereas in the maxilla the largest belong to the inner row.

The hyomandibular articulates with the cranium by a single head.   There is no visible suture between the palatine and the ectopterygoid ; the entopterygoid extends well forward along the inner edge of the palatine, almost to the extremity of that bone. The entopterygoid is thick in the region of the groove in which the parasphenoidal peg is received, and this part of the bone bears strong, curved, pointed teeth, nearly as large as those on the parasphenoid.   Smaller teeth occur on the ectopterygo-palatine bone, a long outer row (really a double row, like the dentition of the maxilla) extending back almost to the quadrate articulation, and a shorter inner row.

The opercular is reduced in size and lies along the upper two-thirds of the preopercular ; its width is about two-fifths of its height.   There is no subopercular.   Several branchiostegal rays are missing from the specimen examined : Peters (*l. c.* p. 196) puts the number as eleven, and Boulenger (*l. c.* p. 120) as nine.

The interhyal is large and ossified ; there is a small upper hypohyal, but no lower ; the urohyal is very small.   Above the glossohyal cartilage and the basibranchials * is a large, triangular, dentigerous bony plate, concave on its upper surface, recalling the similarly placed lingual bone of *Osteoglossum*, except that the width of the hinder part is greater, and that the largest teeth occur in the median line of the plate.   Situated behind this, and lying over a tract of cartilage, is a small, circular, dentigerous

* No basibranchials are to be seen beneath the dentigerous plate in the specimen examined ; they may have been removed in the preparation of the skull, or possibly their absence is to be explained by the basibranchial cartilages failing to ossify.

bone.   Projecting downward from each second hypobranchial is a stout process, similar to that which occurs in the same position in *Osteoglossum* and *Heterotis*. The epipharyngeal teeth of each side are disposed in two contiguous patches.

The foregoing description of the skull of *Pantodon*, read in relation with the summary of the features of the skull in the Osteoglossidæ, points unmistakably towards the existence of a close alliance between the Pantodontidæ and the Osteoglossidæ. The superficial bones of the skull of *Pantodon* are not sculptured, it is true; and the confluence of the right and left premaxillæ is suggestive of the Mormyridæ rather than of the Osteoglossidæ : but, taking the skull as a whole, the evidence is fairly convincing.

The nasals are large and are incorporated into the cranium, and although they do not meet in a median suture as do the nasal bones of the Osteoglossidæ, they resemble these in being suturally united with the anterior edges of the frontal bones. The meeting of the parietal bones in the median line, the smallness of the mesethmoid, the failure of the eye-muscle canal to open posteriorly, the absence of air-vesicles in the hinder part of the cranium, the bounding of the side of the gape by the large maxillary bone, and the absence of a surmaxilla, are characters common to *Pantodon* and the Osteoglossidæ; and—strongest evidence of all—the entopterygoid of *Pantodon* articulates with a lateral peg of the parasphenoid in a manner unknown in any fishes but the Osteoglossidæ.   In the great development of the lingual dentition, in the toothing of the parasphenoid and vomer, and in the fusion of the palatine with the ectopterygoid, *Pantodon* bears a closer resemblance to *Osteoglossum* and *Arapaima* than does *Heterotis* to these; but in the absence of a subopercular, and in the want of a roof to the posterior temporal groove, *Pantodon* departs from *Osteoglossum* and *Arapaima*, and approaches *Heterotis*.

Peters, in the original description of *Pantodon* (*l. c.* p. 200), placed the genus in a special subfamily, the Pantodontes, which he intercalated between two other subfamilies, the Hyodontes (*Hyodon*) and the Osteoglossa (*Heterotis*, *Arapaima*, *Osteoglossum*), the three subfamilies constituting the family Osteoglossidæ.   Günther ('Study of Fishes,' 1880, p. 653) raised the subfamilies of Peters to family rank, making them the Hyodontidæ, Pantodontidæ, and Osteoglossidæ.   Boulenger, in his

recent classificatory scheme of Teleostean fishes (Ann. Mag. Nat. Hist. (7) xiii. 1904, p. 164), has placed the Pantodontidæ and the Osteoglossidæ together, but has separated the Hyodontidæ from them on account of the large size of their supratemporal bone.

From a study of the skull of *Hyodon* (see Journ. Linn. Soc., Zool. xxix. 1904, pp. 206–210), I am disposed to doubt whether any close affinity exists between the Hyodontidæ on the one hand and the Pantodontidæ and Osteoglossidæ on the other; but the results of the present investigation fully justify the action taken by the ichthyologists named in closely associating the Pantodontidæ with the Osteoglossidæ.

PHRACTOLÆMIDÆ.

PHRACTOLÆMUS ANSORGII.

The family Phractolæmidæ (sole genus *Phractolæmus*) is described by Boulenger (Proc. Zool. Soc. 1901, i. pp. 5–7) as occupying a position intermediate between the Osteoglossidæ and the Clupeidæ. This is the reason why the consideration of the skull of *Phractolæmus* is taken here: as will be seen later, the skull bears no close resemblance to that of either family. The skull examined is that belonging to a skeleton in the British Museum marked " *Phractolæmus Ansorgii*, 1901, 1.28.4, Niger Delta." Some of the more important characters of the skull have already been published by Boulenger in the paper above cited.

The cranium is broad, short, and depressed. The frontal bones are very large, and in the specimen examined the right one overlaps the left. The parietals are small and are widely separated by the supraoccipital, which is broad and short. The transverse commissure of the sensory-canal system passes from parietal to parietal through the supraoccipital bone. Projecting from the side of each exoccipital is a large rib which runs outward and somewhat downward, and is attached by ligament to the pectoral girdle. This cranial rib is in serial order with the trunk ribs (although there are no ribs on the first and second vertebræ), and differs from them in being straighter and shorter. There are no Weberian ossicles, and there are no osseous bullæ for lodgment of cæcal diverticula of the swim-bladder. Opening

backwards at the hind end of the cranium, beneath the parietal and above and external to the epiotic, is a shallow depression hardly worthy of the name of fossa, although the position of the depression is that of the posterior temporal fossa.   There is no subtemporal fossa.

The parasphenoid is flat and broad, but becomes narrower immediately beneath the orbits.   It possesses no lateral peg for articulation with the hyopalatine arch, and bears no teeth. There are no posterior wings to the parasphenoid, and the eye-muscle canal does not open behind. The vomer is an edentulous thin plate of bone, square in shape and tilted up in front, and movably hinged to the front of the parasphenoid. The most obvious part of the mesethmoid is a bar of bone with a concave anterior edge, set transversely across the anterior ends of the frontal bones.   In addition to this, however, is a stout endosteal part which can be seen from the front of the skull only, and which extends downward to the posterior end of the vomer.

The hyopalatine arch articulates with the cranium by a single head, and articulates with the prefrontal just lateral of the junction of the vomer with the parasphenoid.   The palatine extends as a thin rod of bone some distance in advance of this. The post-temporal is nearly triangular in shape, but with a notch in front which separates the epiotic limb from the supratemporal limb.   There is no opisthotic limb.   The nasal bones are not recognisable.   Around the eye are five bones—two small rect-angular supraorbitals, one postorbital of moderate size, one suborbital, considerably larger, and in advance of it and of about the same size is another suborbital which nearly touches its fellow of the opposite side below the extreme front part of the head.

The opercular bone articulates in the usual manner with a posterior head of the hyomandibular, and below it is a sub-opercular of about one-sixth its size. . The number of branchio-stegal rays is three. The preopercular is small, barely larger than the subopercular, but its relations are perfectly normal : e. g., it receives the sensory canal from the squamosal, it is attached by fibrous tissue to the outer surface of the hyoman-dibular, and its posterior edge overlaps the front of the opercular bone.   The greater part of the preopercular is concealed by th e postorbital bone.

The interopercular is remarkably large, of about twice the size of the opercular bone; it extends well forward, its pointed anterior extremity nearly reaches the front of the head, and there is a considerable overlapping of the right and left interopercular bones beneath the head. Along the upper edge of the interopercular, and concealed by the overlapping lower edge of the suborbital plate, is a branching sensory canal received from the lower end of the preopercular. The interopercular is thus here performing the function of the missing horizontal limb of the preopercular. This is the only instance known to me in which the sensory canal passes through the interopercular bone: even in *Lepidosteus*, in which the interopercular is situated at the front of the preopercular, the canal does not pass across the interval between the preopercular and the back of the mandible through the interopercular bone, but through the skin (see Collinge, Proc. Birm. Phil. Soc. viii. 2, 1893, p. 265 and pl. 8).

Although the mouth-parts are extremely specialised, the bounding of the gape above is effected, as in the less specialised fishes generally, by the premaxillaries mesially and by the maxillaries laterally. The mouth is very remarkable in form, and is described by Boulenger (*l. c.* p. 6) as "small, proboscidiform, capable of being thrust forward, when at rest folded over and received into a depression on the upper surface of the head." This depression faces upwards, and is bounded in front by the anterior suborbitals and behind by the mesethmoid. When the mouth is withdrawn, the maxillæ lie against the front of the mesethmoid, and rest on the ledge formed by the front of the vomer; but when the mouth is protruded, a large tract of skin intervenes between the maxillæ and the mesethmoid.

The mouth-skeleton, when the mouth is extruded, is almost detached from the other parts of the skull. It forms a ring of bones around the mouth-opening. Each maxilla is slender, curved into an irregular semicircle, the lateral (*i. e.* the morphologically posterior) extremity being expanded and attached by fibrous tissue to the outer surface of the upper extremity of the dentary. The two maxillæ nearly meet in the median plane of the head, and are connected with one another by fibrous tissue. The two premaxillæ are set immediately in front of the mesial ends of the maxillæ; they have the form of flat, triangular plates of bone, and, being small, they support only the upper part of the

mouth-border, leaving the lateral parts of the maxillæ to support the sides. Each mandibular ramus consists of a slender horizontal part, with a large process upstanding from near the symphysial end, somewhat as in the case of *Gonorhynchus*, but more aberrant from the normal proportions. The upstanding parts of the two rami together form a semicircle as viewed from the front, and support the lower part of the border of the gape. At their symphysial ends the rami are loosely united by fibrous tissue, and each bears near its symphysial end a stout, short, conical tooth. These two are the only teeth which the animal possesses; it is not clear what purpose they serve, for they have no hard structure opposed to them against which they might bite.

The quadrate is thrust forward far in advance of its normal position, and the union between the quadrate and mandible is effected in such a manner that the ring of bones surrounding the mouth-opening is freely movable in every direction. The hypohyal is large, and single on each side; there is no descending process of the second hypobranchial; the first basibranchial is unossified.

Even if one dismisses from consideration such aberrant features as those of the mouth-bones, the preopercular and interopercular bones, and the suborbital bones, one cannot recognise in the skull of *Phractolæmus* any characters that might be described as "Osteoglossid." On the other hand, one notes that the nasal bones are not incorporated into the cranium, the parietal bones are separated, the mesethmoid and subopercular bones show no sign of reduction, there is no lateral peg of the parasphenoid for articulation with the hyopalatine arch, there is no lingual nor entopterygoid dentition, the hypohyal is large, there is no descending process of the second hypobranchial, and the branchiostegal rays are as few as three in number.

Comparison of the skull of *Phractolæmus* with that of the Clupeidæ is equally unproductive of positive results, for *Phractolæmus* has no diverticula of the swim-bladder in its pro-otic and squamosal bones, no temporal foramen, no pre-epiotic fossa, no auditory fenestra, no fontanelle between the anterior ends of the frontal bones, no posterior wings to the parasphenoid, no posterior opening to the eye-muscle canal, and no surmaxillæ.

It is to be noted, however, that in respect of all the characters just mentioned, and in the fewness of the branchiostegal rays, in

the reduction of the dentition, and in the forward dislocation
of the quadrate, *Phractolæmus* resembles *Chanos*. In *Chanos* the
relations of the quadrate to the mandibular ramus are normal,
but in consequence of the modification of the mouth-parts the
quadrate is so far thrust forward as to have parted from the
metapterygoid, a most unusual condition. The premaxillæ of
Chanos are thin scales, like those of *Phractolæmus*; these alone
bound the gape above, but if *Chanos* were capable of opening its
mouth as widely as *Phractolæmus*, the hinder parts of the maxillæ
would bound the sides of the gape.

   The main objections to the association of *Phractolæmus* with
Chanos lie in the possession by the latter of a strongly developed
horizontal limb of the preopercular, a fully roofed posterior
temporal fossa of large size, backwardly directed spines projecting
from the squamosal, supraoccipital, and exoccipital bones, an
ossified first basibranchial, and two hypohyals on each side, and
in the small size of its vomer. These objections are not insuper-
able, however, and the resemblance between the skulls of *Phrac-
tolæmus* and *Chanos*, though possibly due to " Convergence," is
sufficiently suggestive to warrant the undertaking of a com-
parative study of the other parts of the body of these fishes
by any one having the necessary time and material at his
disposal.

EXPLANATION OF THE PLATES.

PLATE 30.

Fig. 1. *Osteoglossum Leichardti*. Dorsal view of cranium.
     2.   ,,   ,,   Side view of cranium.
     3.   ,,   ,,   Back view of cranium.
     4.   ,,   ,,   Right side of skull.
     5.   ,,   ,,   Hyopalatine arch of left side, with opercular
                                      bones and mandible, mesial aspect.

PLATE 31.

Fig. 6. *Heterotis niloticus*. Dorsal view of cranium.
     7.   ,,   ,,   Side view of cranium.
     8.   ,,   ,,   Back view of cranium.
     9.   ,,   ,,   Right side of skull.
    10.   ,,   ,,   Hyopalatine arch of left side, with opercular
                                    bones and mandible, mesial aspect.
    11.   ,,   ,,   Occipital half-vertebra, posterior view.

PLATE 32.

Fig. 12. *Arapaima gigas.* Dorsal view of cranium.
13.   ,,   ,,   Side view of cranium.
14.   ,,   ,,   Back view of cranium. ,
15.   ,,   ,,   Right side of skull.
16.   ,,   ,,   Hyopalatine arch of left side, with preopercular
bone and mandible, mesial aspect.

Abbreviations employed in the Figures.

al ... alisphenoid.
an ... angular.
bo ... basioccipital.
c ... centrum of occipital half-
vertebra.
c' ... centrum of the vertebra
behind *c.*
cor ... circumorbital bones.
ct ... cartilage.
d ... dentary.
ecar ... ectosteal articular.
ecp ... ectopterygoid.
enar ... endosteal articular.
enp ... entopterygoid.
eo ... exoccipital.
ep ... epiotic.
f ... frontal.
hm ... hyomandibular.
im ... intermuscular bone.
iop ... interopercular.
me ... mesethmoid.
mpt ... metapterygoid.
mx ... maxilla.
n ... nasal.
op ... opisthotic.
opc ... opercular.

or ... orbitosphenoid.
p ... parietal.
pl ... palatine.
pm ... premaxilla.
pof ... postfrontal.
pop ... preopercular.
pp ... parasphenoidal peg for
articulation with the
entopterygoid.
prf ... prefrontal.
pro ... pro-otic.
ps ... parasphenoid.
pt ... post-temporal.
ptf ... posterior temporal fossa.
q ... quadrate.
r ... rib.
s ... teeth on lingual surface of
dentary.
sar ... sesamoid articular.
soc ... supraoccipital.
sop ... subopercular.
sq ... squamosal.
st ... supratemporal.
stf ... subtemporal fossa.
sy ... symplectic.
v ... vomer.

SKULL OF OSTEOGLOSSUM.

SKULL OF HETEROTIS.

SKULL OF ARAPAIMA.

Experimental Studies on Heredity in Rabbits. (Assisted by the Elizabeth Thompson Science Fund.) By C. C. HURST, F.L.S.

THE following experiments were designed in 1902 with the object of determining whether the Mendelian principles of heredity were applicable to animals as well as plants. For that purpose the domestic Rabbit seemed to be a likely subject, as many of the fancy races were well known to possess distinct structural and colour characters which constantly bred true.

At first, in order to make the experiments as simple as possible, two races only were selected for crossing, White Angora and Belgian Hare. The former is an albino race with pink eyes, swaying habit, and a long Angora coat of fine texture; while the latter is a normal race with pigmented skin, dark eyes, and short yellow-grey fur of coarser texture. An inbred pair of each race was crossed reciprocally, and the hybrids of the first generation were all normal individuals with pigmented skin, dark eyes, short fur, and grey coat like that of the common wild rabbit. Those by the albino buck were all self-coloured, while those from the albino doe were, with one exception, more or less marked with white on the fore extremities. These grey hybrids bred together produced 14 distinct types in the second generation, viz. :—

> Short, normal *, grey, self-coloured.
> Short, normal, grey, marked.
> Short, normal, grey, Dutch-marked.
> Short, normal, black, self-coloured.
> Short, normal, black, marked.
> Short, normal, black, Dutch-marked.
> Short, albino †, white.
> Angora, normal, grey, self-coloured.
> Angora, normal, grey, marked.
> Angora, normal, grey, Dutch-marked.
> Angora, normal, black, self-coloured.
> Angora, normal, black, marked.
> Angora, normal, black, Dutch-marked.
> Angora, albino, white.

* Pigmented, with normal demeanour (see p. 292).
† Unpigmented, with swaying habit (see p. 292).

All the normals had dark eyes and the albinos pink eyes. Several types appeared in the same litter, and each individual hybrid produced all the types.

This epidemic of variation in the second generation of hybrids has been the common experience of experimenters both in animals and plants, and before the Mendelian principles became known remained practically unexplained. By the aid of the Mendelian principles we are able to see at once that there are at least 4 pairs of distinct characters concerned in the offspring of the second generation, each pair being inherited independently of the others, viz.:—Short and Angora coat, normality and albinism, grey and black coat, self-coloured and marked coat.

In order to simplify such a complicated problem, each of these 4 pairs of characters will be dealt with singly, and the offspring of each individual detailed separately. To facilitate this, each individual was numbered as soon as it was used at the stud, which number is reserved solely for that individual throughout its life.

The 4 individuals used at the outset were as follows:—No. 1 doe and No. 4 buck were pure bred Belgian Hares raised out of the same litter. No. 2 buck and No. 3 doe were pure-bred White Angoras, both by the same buck but out of different does.

These 4 individuals were obtained from local fanciers, whose pure and constant strains had been under observation for several years, so that no extensive tests of their purity and constancy were deemed necessary. For the purpose, however, of securing young stock for further experiments, 4 litters, containing 28 individuals, were raised from the pair of Belgians and the pair of Angoras; all of these bred true to their parents in all the characters with which we are concerned.

(1) SHORT AND ANGORA COAT.

The coat of the " Belgian Hare " rabbit, in common with that of the wild rabbit and most of the domesticated races, is made up of short coarse fur, the longest hairs of which seldom exceed one inch.

The coat of the Angora race consists of long, fine wool, the longest hairs of which often exceed six inches.

The two kinds of coat are unmistakable, not only in the

extreme difference in their length, but also in their texture. The Angora coat is finer and softer in texture than the short coat, and, unless constantly combed out, quickly becomes matted and woolly, unlike the short fur, which lies back quite flat.

As already noted, both kinds of coat breed true when mated with their own kind.

(a) *First Generation* (F_1).

No. 1 doe with short coat mated with No. 2 buck with Angora coat produced 26 hybrids with short coats.

The reverse cross, No. 3 doe with Angora coat mated with No. 4 buck with short coat, produced 16 hybrids with short coats. In general appearance the hybrid short coats were indistinguishable from the pure short coat, the influence of the Angora character not being apparent. A careful examination, however, revealed what appeared to be faint traces of the Angora influence in both length and texture. The hairs of the hybrid coat were slightly longer, seemed softer to the touch, and were apparently more densely distributed than in the pure short coat. At the same time it must be admitted that these apparent traces of the Angora influence were so small, that had one not known the Angora parentage it would never have been suspected. In Mendelian terms, therefore, short coat may be said to be dominant over Angora coat, which is recessive.

Further experiments recently carried out show that the short coat of other races, as well as the Belgian Hare, is similarly dominant over the Angora coat. Altogether, 87 hybrids have been raised by crossing shorts with Angoras, and all have short coats, no matter whether the Angora was used as the male or female parent. It appears, therefore, that in these cases the phenomenon of dominance is peculiar to the character itself, and is not in any way influenced by change of sex, change of individual, or change of race.

The following table gives the results of the individual matings. S = pure short coat, A = pure Angora coat, and the numbers attached to these letters refer to the individual animals used. To save repetition, it may be noted that the doe is placed first throughout the matings; *e. g.*, S 1 × A 2 is No. 1 doe with short coat mated with No. 2 buck with Angora coat; Nos. 1, 4, 13, and

25 are Belgian Hares, No. 47 is a Silver Fawn, Nos. 51 and 52 are Dutch, No. 61 is a Himalayan, and Nos. 2, 3, 23, and 50 are Angoras.

TABLE 1.

Shorts × Angoras (F_1).

Matings.		Short.	Angora.
S 1 × A 2	....	26	0
A 3 × S 4	....	16	0
A 3 × S 51	....	8	0
S 13 × A 2	....	4	0
A 23 × S 25	....	13	0
A 23 × S 61	....	7	0
A 50 × S 47	...:.............	8	0
S 52 × A 2	....	5	0
	Total	87	0

(b) *Second Generation* (F_2).

The short-coated hybrids of the first generation bred together produced a mixture of shorts and Angoras in Mendelian proportions. 7 short-coated hybrids bred together produced 171 young, of which 70 were reared to the age of two months or more, when the nature of the coat became evident; of these, 53 had short coats and 17 were Angoras.

The Mendelian expectation for 68 young is 51 shorts and 17 Angoras.

The Angora coats of the second generation were indistinguishable from those of pure-bred Angoras of the same age.

The short coats of the second generation were similar in appearance to those of the pure and hybrid shorts.

Each individual hybrid of the first generation that was tested produced both kinds of coat, usually in the same litter.

The individual results were as follows :—No. 5 gave 6 shorts and 3 Angoras ; No. 7, 8 S and 3 A ; No. 8, 2 S and 2 A ; No. 9, 24 S and 5 A ; No. 10, 37 S and 11 A ; No. 11, 13 S and 4 A ; No. 12, 16 S and 6 A.

The following table gives the individual matings with the details of each litter. H = hybrid of the first generation bred from S × A.

TABLE 2.

Hybrid Shorts bred together (F_2).

Matings.	Short.	Angora.
H 5 × H 12	5	2
H 5 × H 10	1	1
H 7 × H 10	2	1
H 7 × H 10	2	1
H 7 × H 10	4	1
H 8 × H 10	1	1
H 8 × H 10	1	1
H 9 × H 10	7	1
H 9 × H 10	5	2
H 9 × H 10	2	1
H 9 × H 10	4	0
H 9 × H 10	6	1
H 11 × H 12	5	2
H 11 × H 12	6	2
H 12 × H 10	2	0
Total	53	17

The short-coated hybrids of the first generation mated back with the original Angoras produced a mixture of shorts and Angoras in Mendelian proportions. 5 short-coated hybrids mated with Angoras produced 54 young, of which 38 were reared; of these, 20 had short coats similar in appearance to those of the pure and hybrid shorts, while 18 were Angoras indistinguishable from the pure Angoras. The Mendelian expectation for this mating is 19 shorts and 19 Angoras.

Curiously enough, in the first litter H 8 × A 2 produced 5 young, *all Angoras,* while in the second litter there were 3 shorts and 3 Angoras, as expected. The following table gives the numbers obtained in each litter from the individual matings :—

TABLE 3.

Hybrid Shorts × Angoras (F).

Matings.	Short.	Angora.
H 5 × A 2	3	2
H 5 × A 2	5	2
H 7 × A 2	4	3
H 8 × A 2	0	5
H 8 × A 2	3	3
A 3 × H 10	3	3
A 3 × H 12	2	0
Total	20	18

2 short-coated hybrids of the first generation mated back with the original short produced 20 young, of which 17 were reared. All had short coats similar in appearance to the pure and hybrid shorts, in accordance with the Mendelian expectation.

The matings were as follows :—S 1 × H 12 gave 11 shorts in two litters, and S 1 × H 10 gave 6 shorts in one litter.

(c) *Third Generation* (F_3).

The Angoras of the second generation extracted from the hybrid shorts of the first generation bred quite true when mated together and with pure-bred Angoras.

9 extracted Angoras mated together and with Angoras produced 41 Angora young, all indistinguishable from pure-bred Angoras, in accordance with the Mendelian expectation. 26 of these were raised from the extracted Angoras bred together.

The individual matings were as follows. E A = Extracted Angora. Nos. 26, 33, 37, 53, and 54 were extracted from H × H, while Nos. 16, 20, 41, and 42 were extracted from H × A.

TABLE 4.

Extracted Angoras × Angoras (F_3).

Matings.	Short.	Angora.
E A 16 × A 2	0	5
E A 20 × A 2	0	4
E A 33 × A 24	0	6
E A 33 × E A 37	0	7
E A 42 × E A 26	0	6
E A 53 × E A 37	0	7
E A 54 × E A 41	0	6
Total	0	41

The extracted Angoras, like the pure-bred Angoras, proved to be recessive to pure shorts. 4 extracted Angoras mated with 3 pure and 1 extracted short produced 27 short-coated young, similar in appearance to the pure and hybrid shorts.

The matings were as follows (E S = Extracted pure Short):—

Table 5.

Extracted Angoras × Pure Shorts (F_3).

Matings.	Short.	Angora.
E A 15 × S 25	6	0
E A 15 × S 51	8	0
E A 16 × S 61	7	0
E S 34 × E A 37...............	6	0
Total	27	0

The extracted Angoras, like the pure-bred Angoras, gave a mixture of shorts and Angoras when mated with hybrid shorts. 5 extracted Angoras mated with 3 hybrid shorts produced 28 young, of which 17 had short coats and 11 Angoras. The Mendelian expectation is 14 shorts and 14 Angoras.

It will be observed that there is here a slight excess of shorts, which appears to be due to E H 28 giving 12 shorts and 6 Angoras instead of the expected 9 of each. The matings were as follows :—

Table 6.

Extracted Angoras × Hybrid Shorts (F_3).

Matings.	Short.	Angora.
E A 15 × H 12	2	2
E A 15 × E H 28	3	1
E A 16 × E H 28	4	2
E A 16 × E H 28	1	0
E A 20 × E H 28	2	2
E A 33 × E H 28	2	1
E H 31 × E A 26	3	3
Total	17	11

From the above experiments with 10 Angoras extracted from hybrid shorts, it is clear that the extracted Angoras are not only indistinguishable in appearance from pure-bred Angoras, but in their breeding they behave exactly as do the pure-bred Angoras, viz. :—(1) They breed true with one another ; (2) they are recessive to pure shorts ; (3) they give mixed offspring when mated with hybrid shorts.

These facts are all in accordance with the Mendelian conception of gametic purity, and there seems to be no doubt that, notwithstanding their hybrid origin, these extracted Angoras are

pure Angoras, giving off gametes carrying the Angora factor simply, with no trace of the short-coat factor carried (in the case of 5 of them) by both their parents and one-half of their ancestors for several generations and probably many more.

The short-coated individuals of the second generation tested with Angoras and hybrids proved to be of two kinds, pure shorts and hybrid shorts, the former producing all shorts and the latter a mixture of shorts and Angoras.

Out of 16 individuals tested, 5 were extracted from hybrids of the first generation mated back with the original Angoras (H × A), and these all proved to be hybrids in accordance with the Mendelian expectation.

One individual was extracted from a hybrid of the first generation mated back with one of the original shorts (H × S), and this proved to be a hybrid, the Mendelian expectation for 2 such individuals being 1 pure and 1 hybrid.

The remaining 10 individuals were extracted from hybrids of the first generation bred together (H × H), and of these 4 proved to be pure and 6 were hybrids; the Mendelian expectation for 12 such individuals being 4 pure and 8 hybrids.

The 4 pure extracted shorts mated with 3 Angoras and 4 hybrids produced 51 short-coated young, similar in appearance to the pure and hybrid shorts. The matings were as follows:—

TABLE 7.

Extracted Shorts × Angoras and Hybrids (F₃).

Matings.	Short.	Angora.
E S 30 × H 10	5	0
E S 30 × H 10	7	0
E S 32 × A 2	5	0
E S 32 × H 12	4	0
E S 32 × H 10	5	0
E S 34 × E A 37	6	0
E S 34 × E H 14	5	0
E S 36 × E H 28	3	0
E S 36 × H 10	5	0
E S 36 × E A 26	6	0
Total	51	0

The extracted hybrid shorts mated together and also with

Angoras in each case produced a mixture of shorts and Angoras in Mendelian proportions. 10 extracted hybrids mated together and with 2 hybrids of the first generation produced 41 young, of which 31 had short coats and 10 were Angoras ; the Mendelian expectation for 40 young is 30 shorts and 10 Angoras. The matings were as follows :—

TABLE 8.

Extracted Hybrids × Hybrids (F_3).

Matings.	Short.	Angora.
E H 18 × E H 14	2	3
E H 21 × E H 14	5	2
E H 21 × E H 38	5	2
E H 29 × H 10	3	0
E H 29 × E H 27	3	1
E H 31 × H 12	4	0
E H 35 × E H 28	3	1
E H 35 × E H 28	2	0
E H 45 × E H 28	4	1
Total	31	10

7 extracted hybrids mated with 8 Angoras produced 50 young, of which 27 had short coats and 23 were Angoras ; the Mendelian expectation is 25 shorts and 25 Angoras. The matings were as follows :—

TABLE 9.

Extracted Hybrids × Angoras (F_3).

Matings.	Short.	Angora.
E H 17 × A 2	2	3
E H 18 × A 2	2	1
E H 19 × A 2	1	1
E H 21 × A 2	2	2
A 23 × E H 28	2	2
E A 15 × E H 28	3	1
E A 16 × E H 28	1	1
E A 16 × E H 28	4	2
E A 20 × E H 28	2	2
E H 31 × E A 26	3	3
E A 33 × E H 28	2	1
E H 44 × A 24	3	4
Total	27	23

20*

From the above results it would appear that the unit characters, short and Angora coat, in their heredity follow the Mendelian type *Pisum* as regards dominance, segregation, and gametic purity.

(2) NORMALITY AND ALBINISM.

The normal Belgian rabbit has a pigmented skin, coloured coat, dark eyes, and normal demeanour, while the albino Angora has a clear skin devoid of pigment, white coat, pink eyes, and a curious habit of swaying the head from side to side whenever the body is at rest. So far as these experiments go, all these apparently different characters of the albino are correlated and inherited as a single character or unit, which may be simply called albinism as opposed to normality.

In describing these experiments, therefore, it will be understood that the term normal includes a pigmented skin, coloured coat, dark eyes, and normal demeanour, while the term albino comprises a clear skin, white coat, pink eyes, and the swaying habit. As already noted, both the normal Belgians and the albino Angoras breed true when mated with their own kind.

(a) *First Generation* (F_1).

No. 1 normal doe mated with No. 2 albino buck produced 26 normal hybrids. The reverse cross, No. 3 albino doe mated with No. 4 normal buck, produced 16 normal hybrids. The 26 normal hybrids of the first cross did not show the slightest trace of the albino parentage in any respect. The 16 normal hybrids of the reverse cross (with one exception) had a few white markings on the fore extremities, but, as will be seen later, these do not seem to be connected with simple albinism at all, but rather with the Dutch markings latent in the albino (see under Sect. 4, p. 314). In Mendelian terms, therefore, normality may be said to be dominant over albinism, which is recessive.

Further experiments recently carried out show that the normal character of other races as well as the Belgian is similarly dominant over albinism. Altogether 94 hybrids have been raised by crossing normal and albino individuals and all have proved to be normal hybrids, whether the albino was used as the male or the female parent. It appears that in these cases also the phenomenon of dominance is peculiar to the character itself, and is not influenced by change of sex, individuals, or race. The

individual matings were as follows. N = normal, A = Albino. No. 47 is a Silver Fawn; Nos. 51 and 52 are Dutch; Nos. 1, 4, 13, and 25 are Belgians; and Nos. 2, 3, 6, 23, and 50 are Angoras.

TABLE 10.

Normal × Albino (F_1).

Matings.		Normal.	Albino.
N 1 × A 2	....	26	0
A 3 × N 4	....	16	0
A 3 × N 51	....	11	0
A 6 × N 4	....	8	0
N 13 × A 2	....	4	0
A 23 × N 25	....	16	0
A 50 × N 47	....	8	0
N 52 × A 2	....	5	0
Total	....	94	0

(b) *Second Generation* (F_2).

The normal hybrids of the first generation bred together produced a mixture of normals and albinos in Mendelian proportions. 7 normal hybrids bred together produced 171 young, of which 132 were normal and 39 were albinos. The Mendelian expectation for 172 young is 129 normals and 43 albinos.

Each individual hybrid that was tested produced both normals and albinos, usually in the same litter. The individual results were as follows:—No. 5 gave 13 normals and 4 albinos; No. 7, 22 N and 9 A; No. 8, 28 N and 4 A; No. 9, 43 N and 14 A; No. 10, 92 N and 24 A; No. 11, 26 N and 8 A; and No. 12, 40 N and 15 A.

It will be observed that No. 8 gives a decided *deficiency* of albinos, while, as will be seen later, the same individual in a previous litter gave an unexpected *excess* of albinos when mated with an albino.

The albinos of the second generation extracted from the normal hybrids of the first generation had apparently the same albinic characters as the original albino grand-parents, viz., a clear skin devoid of pigment, pure white coat, pink eyes, and the swaying habit.

The normals of the second generation had apparently the same normal characters as the original normal grand-parents and the

normal parents, viz., a pigmented skin, coloured coat, dark eyes, and normal demeanour. The majority were self-coloured like the original normals, while some were slightly marked with white on the fore extremities, and a few were marked like the pure Dutch rabbit. As will be seen later, these Dutch markings are apparently not connected with simple albinism (see under Sect. 4, p. 314).

The following table gives the individual matings with the details of each litter :—

TABLE 11.

Hybrid Normals bred together (F₂).

Matings.		Normal.	Albino.
H 5 × H 12	....	6	3
H 5 × H 10	....	7	1
H 7 × H 10	....	4	4
H 7 × H 10	....	3	1
H 7 × H 10	....	7	2
H 7 × H 12	....	8	2
H 8 × H 10	....	8	1
H 8 × H 10	....	8	1
H 8 × H 10	....	8	1
H 8 × H 10	....	4	1
H 9 × H 10	....	8	0
H 9 × H 10	....	5	2
H 9 × H 10	....	6	2
H 9 × H 10	....	7	1
H 9 × H 10	....	7	2
H 9 × H 10	....	4	3
H 9 × H 12	....	6	4
H 11 × H 12	....	6	2
H 11 × H 12	....	7	1
H 11 × H 12	....	7	3
H 11 × H 10	....	6	2
	Total	132	39

The normal hybrids of the first generation bred back with the original albinos produced a mixture of normals and albinos in Mendelian proportions.

5 normal hybrids mated with 2 albinos produced 54 young, of which 25 were normals and 29 were albinos. The Mendelian

expectation is 27 normals and 27 albinos. Each hybrid tested produced both kinds, usually in the same litter, but, curiously enough, H 8 × A 2 gave in the first litter 5 young *all albinos*, while in the second litter there were 6 normals and 2 albinos, instead of the expected 4 of each. It will be noted that H 8 was the individual which gave a *deficiency* of albinos in the 4 succeeding litters when mated with H 10. The individual matings were as follows :—

TABLE 12.

Hybrid Normals × Albinos (F_2).

Matings.	Normal.	Albino.
H 5 × A 2	2	2
H 5 × A 2	4	1
H 5 × A 2	3	4
H 7 × A 2	3	4
H 8 × A 2	0	5
H 8 × A 2	6	2
A 3 × H 10	4	2
A 3 × H 10	2	5
A 3 × H 12	1	4
Total	25	29

2 normal hybrids of the first generation mated with one of the original normals produced 20 young, all normals. The matings were N 1 × H 12, producing 11 young in 2 litters, and N 1 × H 10, producing 9 young in 1 litter. The Mendelian expectation is, of course, all normals.

(c) *Third Generation* (F_3).

The albinos of the second generation extracted from the hybrid normals of the first generation bred true when mated with one another and with other albinos, in accordance with the Mendelian expectation. 4 extracted albinos mated together and with 2 other albinos produced 21 young, all of which were albinos. The matings were as follows :—

TABLE **13**.

Extracted Albinos × Albinos (F_3).

Matings.	Normal.	Albino.
E A 16 × A 2	0	5
E A 16 × A 61	0	7
E A 34 × E A 14	0	5
E A 45 × A 61	0	4
Total	0	21

The extracted albinos, like the pure-bred albinos, proved to be recessive to pure normals.

6 extracted albinos mated with 3 pure and 3 extracted normals produced 62 young, all of which were normals, in accordance with the Mendelian expectation.

The individual matings were as follows (E N = Extracted pure normal) :—

TABLE **14**.

Extracted Albinos × Pure Normals (F_3).

Matings.	Normal.	Albino.
E A 15 × N 25	6	0
E A 15 × E N 28	4	0
E A 15 × N 51	8	0
E A 16 × E N 28	6	0
E A 16 × E N 28	6	0
E A 34 × N 49	8	0
E A 39 × N 51	2	0
E A 39 × N 51	6	0
E N 43 × E A 14	7	0
E N 44 × E A 14	4	0
E A 45 × E N 28	5	0
Total	62	0

The extracted albinos, like the pure-bred albinos, gave a mixture of normals and albinos in Mendelian proportions when mated with hybrid normals. 5 extracted albinos mated with 6 hybrid normals produced 47 young, of which 23 were normals and 24 were albinos. The Mendelian expectation for 48 young is 24 normals and 24 albinos.

The matings were as follows (E H = Extracted hybrid) :—

TABLE 15.

Extracted Albinos × Hybrid Normals (F_3).

Matings.	Normal.	Albino.
E A 15 × H 12	4	3
E H 18 × E A 14	4	2
E H 19 × E A 14	1	4
E H 19 × E A 14	2	4
E H 21 × E A 38	5	2
E H 21 × E A 14	3	4
E A 34 × E H 37	2	4
E A 39 × E H 41	2	1
Total..............	23	24

From the above experiments with albinos of the second gene-
ration extracted from the normal hybrids of the first generation
it is clear that not only are the extracted albinos indistinguishable
in their albinism from the pure-bred albinos, but in their breeding
they behave precisely as do the pure-bred albinos, viz.:—(1) They
breed true with one another; (2) they are recessive to pure
normals; (3) they give mixed offspring when mated with hybrid
normals. These facts are all in accordance with the Mendelian
conception of gametic purity; and there seems to be no doubt that,
notwithstanding their hybrid origin, these extracted albinos are
pure albinos.

The normal individuals of the second generation, tested with
albinos and hybrids, proved to be of two kinds, pure and hybrid;
the former producing all normals, and the latter a mixture of
normals and albinos. Out of 21 individuals tested, 7 were
extracted from hybrids of the first generation mated back with
the original albinos (H × A), and these all proved to be hybrids
in accordance with the Mendelian expectation. 2 individuals
were extracted from 2 hybrids of the first generation mated back
with the original normal (H × N), and these have so far proved
to be pure normals; the Mendelian expectation for 2 such indi-
viduals is 1 pure and 1 hybrid. The remaining 13 individuals
were extracted from hybrids of the first generation bred together
(H × H), and of these 4 proved to be pure normals and 9 were
hybrid normals; the Mendelian expectation for 12 such individuals
is 4 pure and 8 hybrids.

The 6 pure extracted normals mated with 4 albinos and 8 hybrids
produced 83 young, all normals in accordance with the Mendelian
expectation. The individual matings were as follows :—

TABLE **16**.

Extracted Normals × Albinos and Hybrids (F₃).

Matings.	Normal.	Albino.
H 7 × E N 28	7	0
A 23 × E N 28	6	0
E N 32 × A 2	7	0
E N 44 × A 24	7	0
E H 20 × E N 28	6	0
E N 30 × H 10	5	0
E N 30 × H 10	7	0
E N 32 × H 12	5	0
E N 32 × H 10	5	0
E N 32 × H 10	6	0
E H 33 × E N 28	6	0
E N 35 × E H 26	6	0
E H 36 × E N 28	3	0
E N 43 × E A 14	7	0
Total	83	0

The extracted hybrid normals mated together, and also with
albinos, in each case produced a mixture of normals and albinos
in Mendelian proportions.   10 extracted hybrids mated together
and with 2 hybrids of the first generation produced 55 young,
of which 38 were normals and 17 were albinos ; the Mendelian
expectation for 56 young is 42 normals and 14 albinos.   The
excess of albinos appears to be due to the peculiarity of E H 26,
which gave 11 normals and 9 albinos instead of the expected 15
and 5.   The individual matings were as follows :—

TABLE **17**.

Extracted Hybrids × Hybrids (F₃).

Matings.	Normal.	Albino.
E H 29 × H 10	5	2
E H 29 × E H 27	5	1
E H 31 × H 12	3	1
E H 31 × E H 26	3	3
E H 36 × H 10	4	1
E H 36 × E H 26	4	4
E H 42 × E H 26	4	2
E H 53 × E H 37	6	1
E H 54 × E H 41	4	2
Total	38	17

8 extracted hybrids mated with 5 albinos produced 89 young, of which 44 were normals and 45 were albinos; the Mendelian expectation for 90 young is 45 normals and 45 albinos. The individual matings were as follows:—

TABLE **18.**

Extracted Hybrids × Albinos (F_3).

Matings.	Normal.	Albino.
E H 17 × A 2	2	1
E H 17 × A 2	5	3
E H 18 × A 2	2	3
E H 18 × A 2	2	3
E H 18 × A 2	1	3
E H 18 × E A 14	4	2
E H 18 × A 2	4	1
E H 19 × A 2	2	3
E H 19 × E A 14	1	4
E H 19 × E A 14	2	4
E H 20 × A 2	3	1
E H 21 × A 2	4	0
E H 21 × A 2	2	3
E H 21 × E A 14	3	4
E H 33 × A 24	3	5
E A 34 × E H 37	2	4
E A 39 × E H 41	2	1
Total	44	45

From the above results it would appear that the unit characters normality and albinism in their heredity also follow the Mendelian type *Pisum* as regards dominance, segregation, and gametic purity.

(3) COAT COLOUR.

The grey coat of the common wild rabbit is made up for the most part of yellow hairs based and tipped with black. The extent of the coloured portions is somewhat variable in individual hairs; generally, however, the black basal portion is more extensive than the yellow middle portion, while the black apical tip is less. In these parti-coloured hairs both the yellow and black pigments occur in different dilutions. Thus, in the patch of short fluffy hairs behind the ears the yellow portion of each hair is a bright tan-yellow; while along the back, towards the tail and

down the flanks on each side, the yellow becomes more diluted, passing from tan through fawn, buff, and cream to white under the tail and belly, where the yellow pigment is not evident.   In the same way the black portions of the hairs, both basal and apical, become diluted, passing from dense black through blue-black, slate-grey, and grey-white to white.

This dilution of the black pigment is especially noteworthy in the roots of the hairs, giving the impression of a blue-black ground-colour close to the skin, when the hairs are blown aside. A certain amount of chocolate or brown pigment appears to be always associated with the black.

Amongst the parti-coloured yellow and black hairs which go to form the grey coat there are a few long black hairs scattered more or less regularly, especially along the back and loins and on the ears and forehead.   These long black hairs give a wavy appearance to the coat, known to fanciers as "ticking"; they are more or less shaded with brown, have blue-black roots, and do not usually appear until about the age of two months.

The above observations show that the hairs which make up the grey coat of the wild rabbit contain at least two distinct pigments— yellow and black, with their dilutions; and most probably a third, brown or chocolate, which is more or less evident in close association with the black pigment.   (*Cf.* Mr. Bateson's, Miss Durham's, and Dr. Allen's observations on similar pigments in Mice: Bateson, 1903; Allen, 1904.)

The yellow-grey coat of the Belgian rabbit used in these experiments contains the same pigments, and is in all respects similar in nature to that of the wild grey, except that it contains a larger proportion of yellow pigment and less black in the individual parti-coloured hairs in all parts of the coat.   This increase of yellow and reduction of black appears to affect the basal part of the hairs more than the tips.

Further, the bright tan-yellow, which is usually confined to the space behind the ears in the wild grey, is extended to the chest and flanks in the yellow-grey, though this also shades off, downward and backward, through fawn, buff, and cream, to white, as in the wild grey.   The creamy-white hairs borne underneath in the wild grey have blue-black roots, giving them a grey-white appearance; while those of the yellow-grey in the same place have apparently no trace of the diluted black pigment, being almost pure white.   The long black hairs also appear to be less in number

in the yellow-grey than in the wild grey, and do not extend so far down the flanks. In all respects, therefore, the yellow-grey has more yellow and less black pigment than the wild grey.

The yellow-grey type breeds perfectly true to the above colour-details, and can always be distinguished from the wild grey.

The coat of the albino Angora is of course pure white, with no trace of any kind of pigment.

(a) *First Generation* (F_1).

The yellow-grey Belgians crossed with the white Angoras gave hybrids all of which had wild-grey coats, no matter which way the cross was made.

No. 1 yellow-grey doe mated with No. 2 white buck produced 26 young with coats indistinguishable from those of the wild grey. In the reverse cross, No. 3 white doe mated with No. 4 yellow-grey buck, gave 16 young, all with wild-grey coats. One individual (No. 7) from the latter mating had, when young, rather more yellow on the chest and flanks than the others ; but after the second moult it became almost wild grey, like the rest. Further experiments recently carried out have given similar results : altogether 70 individuals have been raised by mating yellow-grey with white, and all have wild-grey coats. The following table gives the results of the individual matings ($Y G =$yellow-grey, $W =$white):—

TABLE 19.

Yellow-grey $\times$ White (F_1).

Matings.	Wild Grey.
Y G 1 $\times$ W 2	26
W 3 $\times$ Y G 4	16
W 6 $\times$ Y G 4	8
Y G 13 $\times$ W 2	4
W 23 $\times$ Y G 25	16
Total	70

(b) *Second Generation* (F_2).

The greys of the first generation bred together, with one exception, proved to be hybrid greys containing recessive black, giving a mixture of greys and blacks, the exception giving all

greys. 7 greys of the first generation were tested together, and of these 6 proved to be hybrids, giving both grey and black young, usually in the same litter : the remaining one has so far given no blacks, and presumably is a pure grey.

The pure grey doe (No. 7) mated with 2 hybrid greys containing latent black (Nos. 10 and 12) produced 22 grey young.

The 6 hybrid greys mated together produced 110 coloured young, of which 85 were greys and 25 were blacks.

The individual results were as follows :—No. 5 gave 8 greys and 5 blacks ; No. 8, 22 G and 6 B ; No. 9, 33 G and 10 B ; No. 10, 59 G and 19 B ; No. 11, 22 G and 4 B ; and No. 12, 26 G and 6 B.

All the 7 individuals gave white as well as coloured offspring ; but these have already been dealt with under albinism (Sect. 2, p. 294).

The following table gives the individual matings, with the numbers of greys and blacks in each litter :—

TABLE 20.

Hybrid Greys bred together (F_2).

Matings.	Grey.	Black.
H 5 × H 12	4	2
H 5 × H 10	4	3
H 8 × H 10	5	3
H 8 × H 10	8	0
H 8 × H 10	6	2
H 8 × H 10	3	1
H 9 × H 10	5	3
H 9 × H 10	5	0
H 9 × H 10	5	1
H 9 × H 10	7	0
H 9 × H 10	2	5
H 9 × H 10	3	1
H 9 × H 12	6	0
H 11 × H 12	5	1
H 11 × H 12	6	1
H 11 × H 12	5	2
H 11 × H 10	6	0
Total	85	25

The greys of the second generation had wild-grey coats like their parents, a few individuals appeared to have rather more

yellow and less black than the wild grey; but, curiously enough, not one was a true yellow-grey like the Belgian grand-parent. The blacks of the second generation had black coats with no trace of the yellow pigment of the grey parents; all appeared to be shaded more or less with the brown pigment which is always associated with black, especially when the coat is moulting.

The nest coat was jet-black, but, in common with other black rabbits, after the first moult a few white hairs appeared, chiefly on the back and loins; these apparently increase in number with each moult, and a few have already developed these white hairs to such an extent as to almost resemble the well-known " Silver Grey " breed of the fanciers (" Chinchilla " of Darwin). It is hardly necessary to say that the so-called " Silver Grey " has no resemblance whatever to the wild grey, being a pure black breed when young; afterwards a number of white hairs appear among the black, giving it that silvered appearance so much admired by fanciers. The black individuals were easily distinguished from the grey ones at birth, their pigmented skin being a shade darker and covering the whole body, unlike the greys, in which the ventral area is but little pigmented, being pink or flesh-coloured.

The hybrid greys of the first generation, mated back with one of the original whites, also gave a mixture of greys and blacks, but only a few were raised.

The matings were as follows:—H 5 × W 2⅞ gave 6 greys and 3 blacks, and H 8 × W 2 gave 5 greys and 1 black.

(c) *Third Generation* (F_3).

The blacks of the second generation extracted from the hybrid greys of the first generation have, so far, bred true when mated with one another *. 5 individuals tested together gave 16 young, all blacks with no trace of yellow pigment. The following were the matings: E B 20 × E B 28 gave 6 blacks; E B 33 × E B 28 gave 6 blacks; and E B 54 × E B 41 gave 4 blacks. (For further results showing the purity of the extracted blacks, see Table 22.)

One of the extracted blacks E B 28 was mated with the pure grey G 7, producing 7 grey young.

* Excluding the albinos thrown, which have been already dealt with under Sect. 2, p. 298.

The same extracted black was also mated with a hybrid grey E H 35, producing 2 greys and 5 blacks.

The greys of the second generation have, so far as tested, proved to be of two kinds, pure and hybrid, the former giving all greys, and the latter a mixture of greys and blacks. Out of 9 greys tested, 8 have proved to be hybrids containing recessive black, each of the 8 gave a mixture of greys and blacks, and in all there were 48 young, of which 38 were greys and 10 were blacks.

The matings were as follows :—

TABLE 21.

Hybrid Greys bred together (F_3).

Matings.	Grey.	Black.
E H 29 × H 10	4	1
E H 29 × E H 27	4	1
E H 30 × H 10	4	1
E H 30 × H 10	5	2
E H 31 × H 12	2	1
E H 31 × E H 26	3	0
E H 32 × H 12	5	0
E H 32 × H 10	4	1
E H 35 × E H 26	5	1
E H 42 × E H 26	2	2
Total	38	10

The remaining grey has, so far as tested, proved to be a pure grey, giving 11 grey young when mated with a black and with 2 hybrid greys. The matings were :—E G 36 × E B 28 giving 3 greys ; E G 36 × H 10 giving 4 greys ; and E G 36 × E H 26 giving 4 greys. As these numbers are few, it is possible that this individual may yet prove to be a hybrid grey containing recessive black, and further experiments are necessary before we can be quite sure that it is a pure grey, especially as all the other 8 greys tested proved to be hybrids.

Both the greys and blacks of the third generation had similar coats to those of the second generation, there being still no return to the original yellow-grey of the Belgian.

Summary of Coat-Colour Results.

In the first generation (F_1) yellow-grey × white gave all wild greys. In the second generation (F_2), with one exception, the F_1 greys proved to be hybrids containing recessive black, for, when bred together, they gave a mixture of greys and blacks in Mendelian proportions. In the third generation (F_3) the F_2 blacks have so far bred true when mated together ; they are recessive to pure grey and give a mixture of greys and blacks when mated with hybrid greys. The F_2 greys so far appear to be of two kinds, pure and hybrid, and the hybrids bred together give a mixture of greys and blacks in Mendelian proportions. From the Mendelian point of view the above results are what might have been expected had the original parents been grey × black instead of yellow-grey × white.

Two points therefore appear to demand consideration :— The appearance of the black character, and the disappearance of the yellow-grey character.

The Appearance of the Black Character.

The sudden appearance of the black character in the second generation was quite unexpected, as there had been no black individuals in the ancestry of either of the original parents— Belgian or Angora—for at least 8 generations and probably many more. The fact that these black individuals appeared in about the proportion of one quarter and bred true at once was very significant from the Mendelian point of view. It suggested that the hybrid greys of the first generation were giving off gametes, one half of which contained the factor for black coat-colour. As these hybrid greys were bred from the yellow-grey Belgians crossed with the white Angora, it appeared that the black factor must have been introduced by one or the other of these parents, or by both.

That it was not introduced by both is clear from the absence of blacks in the first generation. That it was not introduced by the Belgian is equally clear from the fact that no blacks appeared when the Belgian was mated with a pure black, nor when the Belgians were mated together. From the Mendelian point of view, therefore, it would appear that the black factor must have been introduced by the white Angora. This may appear incredible, and yet, as the following experiments show, it seems to be the only interpretation of the facts.

Colour-factors latent * in Pure-bred Albinos.

The 2 albino Angoras originally used in the experiments were tested by mating them with the pure blacks of the second generation. No. 2 albino buck mated with 4 black does gave 16 black young. No. 3 albino doe mated with a black buck gave 11 young, of which 5 were black and 6 were grey. These results are in accordance with the conception that No. 2 albino gave off gametes, all of which carried the black factor, while No. 3 albino gave off gametes, some of which carried the black factor and others the grey factor.

To test the matter still further, No. 2 albino was mated with 5 grey hybrids known to contain recessive black, producing 38 coloured young, of which 21 were greys and 17 were blacks. If, as conceived, No. 2 albino was carrying latent black simply, the Mendelian expectation in this mating is 19 greys and 19 blacks. Again, No. 3 albino was mated with 2 grey hybrids known to contain recessive black, producing 7 coloured young, of which 5 were greys and 2 were blacks. These numbers are few, but if, as conceived, No. 3 albino was carrying both latent grey and latent black factors, the Mendelian expectation for 8 young is 6 greys and 2 blacks. This conception also explains certain facts in regard to the gametic constitution of the individuals of the first generation which are otherwise obscure. It will be remembered that while all the greys of the first generation by the No. 2 albino were hybrids containing recessive black, yet one individual grey (No. 7) out of No. 3 albino was a pure grey containing no black. The above conception that No. 2 albino gave off all black gametes, while No. 3 albino gave off both grey gametes and black gametes would explain the above facts, which were previously obscure.

In order to test whether these latent factors in albinos were subject to Mendelian segregation in simple albino matings, the No. 3 albino doe, apparently carrying grey and black, was mated with No. 2 albino buck, apparently carrying black only. 14 young were produced, all albinos, of course, with no trace of

* To prevent misconception it should be stated that the colour-factors present in albinos are "*latent*" in the sense that their influence is not evident until some other ingredient, found in a pigmented individual, is added to them. When the precise nature of pigmentation is determined, it may be possible to substitute a more precise term. (*Cf.* Cuénot, 1903.)

pigment. 2 of these young were tested with pure blacks and have so far given the following results :—

No. 23 albino doe mated with a pure black gave 5 blacks and 1 grey. No. 24 albino buck mated with a pure black gave 3 blacks : mated with a grey hybrid containing recessive black gave 6 blacks and 1 grey.

Although these results are few in number, yet it seems certain that No. 23 albino is carrying both grey and black, while No. 24 is apparently carrying black only.

The Mendelian expectation for albino (gr.-bl.) × albino (bl.) is 1 albino (gr.-bl.) and 1 albino (bl.), which is apparently the result. The fact that in this case father and son are apparently carrying black only, while mother and daughter are apparently carrying grey and black, may be but a coincidence.

All the above results with pure-bred albinos are in accordance with the conception that albinos give off gametes carrying certain colour-factors which remain latent until the albino is crossed with a pigmented individual, and yet, during their latency, obey the Mendelian laws of segregation and gametic purity. Further support is given to this conception by the results of the following experiments with extracted albinos.

Colour-factors latent in Extracted Albinos.

7 extracted albinos were tested for latent colour-factors, and of these, 2 apparently carried black only, while 5 apparently carried both grey and black. No. 14 albino buck mated with 2 pure blacks gave 6 blacks : mated with 2 grey hybrids containing recessive black it gave 3 greys and 5 blacks.

No. 45 albino doe mated with two pure blacks gave 9 blacks. These two albinos, which were apparently carrying black only, were extracted from No. 5 grey hybrid containing black, mated with No. 2 albino apparently carrying black, and are interesting as showing that albinos apparently carrying black only can be extracted from greys provided that the latter also contain black. No. 15 albino doe mated with 2 pure blacks gave 5 greys and 7 blacks ; this albino was extracted out of No. 8 grey (bl.) × No. 2 albino (bl.).

No. 16 albino doe mated with a pure black gave 7 greys and 5 blacks; this albino was extracted out of No. 7 pure grey × No. 2 albino (bl.).

This case is interesting as showing that an albino extracted out of a pure grey does not necessarily carry grey only, the result depends upon both parents.

No. 34 albino doe mated with a pure black gave 4 greys and 4 blacks ; this albino was extracted out of No. 11 grey (bl.) × No. 12 grey (bl.).

No. 38 albino buck mated with a pure black gave 3 greys and 2 blacks.

No. 39 albino doe mated with two pure blacks gave 6 greys and 4 blacks.

The last two albinos were extracted from No. 7 pure grey × No. 10 grey (bl.).

The three following tables give the individual matings in the testing of the pure-bred and extracted albinos for their latent colour-factors.

4 albinos apparently carrying black only mated with 7 pure blacks gave 34 black young, in accordance with the Mendelian expectation. These 34 blacks may therefore be added to the 16 already recorded under extracted blacks bred together (p. 303) making 50 in all, and will serve as a further illustration of the purity of the black recessives.

TABLE 22.

Albino (black) × Black.

Matings.	Grey.	Black.
E B 19 × A 2	0	2
E B 19 × E A 14	0	3
E B 20 × A 2	0	3
E B 21 × A 2	0	4
E B 21 × A 2	0	2
E B 21 × E A 14	0	3
E B 33 × A 24	0	3
E A 45 × E B 28	0	5
E A 45 × B 61	0	4
B 52 × A 2	0	5
Total	0	34

7 albinos apparently carrying both grey and black mated with 5 pure blacks gave 64 young, of which 32 were greys and 32 were blacks, which is exactly the Mendelian expectation.

TABLE **23.**

Albinos (grey and black) × Black.

Matings.	Grey.	Black.
A 3 × B 51	3	3
A 3 × B 51	3	2
A 23 × E B 28	1	5
E A 15 × E B 28	2	2
E A 15 × B 51	3	5
E A 16 × E B 28	3	3
E A 16 × E B 28	4	2
E A 34 × B 49	4	4
E B 21 × E A 38	3	2
E A 39 × E B 41	2	0
E A 39 × B 51	0	2
E A 39 × B 51	4	2
Total	32	32

3 albinos, apparently carrying black only, mated with 6 grey hybrids containing black, gave 53 young, of which 25 were grey and 28 were black; the Mendelian expectation for 54 young being 27 greys and 27 blacks.

The results of the last table and this may also be added to the results given previously under hybrid greys mated with extracted blacks, giving in all 124 young, of which 59 were greys and 65 were blacks. The Mendelian expectation is 62 greys and 62 blacks (see p. 303).

TABLE **24.**

Albino (black) × Grey (black).

Matings.	Grey.	Black.
H 5 × A 2	2	0
H 5 × A 2	1	3
H 5 × A 2	3	0
H 8 × A 2	5	1
E H 17 × A 2	2	0
E H 17 × A 2	1	4
E H 18 × A 2	0	2
E H 18 × A 2	0	2
E H 18 × A 2	0	1
E H 18 × A 2	3	1
E H 18 × E A 14	1	3
E H 32 × A 2	4	3
E H 44 × E A 14	2	2
E H 44 × A 24	1	6
Total	25	28

The above results point to the following conclusions :—

(1) That both pure-bred and extracted albinos carry in their gametes certain colour-factors.

(2) Some albinos give off gametes containing the black factor only, while others give off gametes containing black and gametes containing grey, on the average in equal numbers.

(3) These colour-factors remain latent when albinos are mated together, but become patent when the albinos are mated with normal individuals.

(4) These latent colour-factors appear to follow the ordinary Mendelian rules of segregation and gametic purity.

(5) That the black character, which appeared in the second generation of the hybrids between the yellow-grey Belgian and the white Angora, was introduced by the albino Angora.

These conclusions, arrived at from experiments with Rabbits, fully confirm those already obtained by Prof. Cuénot in his important experiments with Mice ; and although of necessity my experiments have been carried out on somewhat different lines, yet the conclusions are the same in principle, and in presenting them I wish to acknowledge my indebtedness to Prof. Cuénot and Mr. Bateson for their useful suggestions. There is no doubt that the demonstration of the fact of latent colour-factors being carried by albinos is of great significance, and will help to throw light upon a large number of observations, contributed by many observers in both animals and plants, that hitherto have remained obscure.

The Disappearance of the Yellow-grey Character.

With regard to the disappearance of the original yellow-grey character of the Belgian in all the generations, a number of experiments are now in progress, which, it is hoped, will throw some light upon the matter as soon as completed *.

(4) Uniform and Marked Coat.

In the original experiments the Belgian parents had a uniform or self-coloured coat, with no trace of white markings on the extremities. (The almost white ventral area may for this purpose be disregarded.)

This self-colour character breeds true, so far as my experiments

* So far it is not possible to suggest what is the meaning of the non appearance of the Belgian coat-colour in F_2 and F_3.

go, and to my knowledge for at least 8 previous generations and probably many more.

The 2 pure self-coloured Belgians were mated with 2 albino Angoras, and each albino gave a different result.

No. 2 albino buck mated with No. 1 self-coloured doe produced 26 self-coloured young with no trace of white markings on the extremities.

No. 3 albino doe mated with No. 4 self-coloured buck produced 16 young, of which one only was self-coloured, all the others being more or less marked with white on the fore-feet, shoulders, breast, nose, and forehead.

These white markings, though variable in extent, increased in a definite direction. The slightest markings were either on the tip of a fore-paw or at the end of the nose; as the markings increased they invaded the whole fore-feet, legs, shoulders, and breast, while the nose-markings extended towards the forehead; in other words, the whole tendency of the markings was towards the Dutch markings, so well known to fanciers. No. 7 was self-coloured, while No. 10 had white fore-feet, legs, right shoulder, and breast, being the most marked of all; the others might be said to consist of a series between Nos. 7 and 10.

As different results were obtained from the 2 albinos, it is necessary to consider the offspring of the 2 lines of descent separately, viz. :—The self-coloured line raised from the No. 2 albino, and the marked line raised from the No. 3 albino.

(a) *The Self-coloured Line.*

In the first generation all the offspring were self-coloured. In the second generation 3 of the selfs of the first generation bred together and with a pure self produced 37 young, of which 35 were selfs and 2 were slightly marked with white, having a few white hairs on the tip of the right paw. The matings were as follows :—

TABLE 25.

Self × Self (F_2).

Matings.	Self.	Marked.
S 1 × S 12	11	0
S 5 × S 12	5	1
S 11 × S 12	19	1
Total	35	2

In the third generation 5 of the selfs of the second generation mated together and with 2 pure selfs produced 25 young, all self-coloured. The matings were as follows :—

TABLE 26.

Self × Self (F₃).

Matings.	Self.	Marked.
S 31 × S 12	3	0
S 31 × S 26	3	0
S 32 × S 12	5	0
S 42 × S 26	4	0
S 43 × S 25	10	0
Total	25	0

In the self-coloured line therefore, with two slight exceptions, the selfs bred true for three generations, including 88 individuals, notwithstanding that all were originally bred from an albino.

(b) *The Marked Line.*

In the first generation all the offspring, except one, were more or less marked with white on the fore extremities. In the second generation, 4 of the individuals of the first generation bred together produced 67 young, of which 16 were selfs, 34 were slightly marked with white like the parents, and 17 had the true Dutch markings. The individual numbers were as follows :—No. 7 gave 5 selfs, 2 marked, and 6 Dutch ; No. 8 gave 3 selfs, 9 marked, and 6 Dutch; No. 9 gave 8 selfs, 23 marked, and 5 Dutch. It will be noted that each individual gave all three kinds; that No. 7, the self-coloured exception, gave more than the average number of full Dutch-marked and also of selfs ; that No. 9, the one most marked with white, gave less than the average number of Dutch-marked. The individual matings and details of each litter were as follows (S=self-coloured hybrid, M = marked hybrid) :—

TABLE 27.

Hybrid Self and Marked × Marked (F₂).

Matings.	Self.	Marked.	Dutch.
S 7 × M 10	1	1	1
S 7 × M 10	2	0	1
S 7 × M 10	2	1	4
M 8 × M 10	0	4	4
M 8 × M 10	2	4	2
M 8 × M 10	1	1	0
M 9 × M 10	2	6	0
M 9 × M 10	1	4	0
M 9 × M 10	0	4	2
M 9 × M 10	2	4	1
M 9 × M 10	1	4	1
M 9 × M 10	2	1	1
Total	16	34	17

In the third generation, 3 of the extracted selfs bred together and with a pure self produced 15 young, of which 14 were selfs and 1 was slightly marked with white on the tip of the left paw. The matings were as follows :—

TABLE 28.

Extracted Selfs × Selfs (F₃).

Matings.	Self.	Marked.	Dutch.
E S 35 × E S 26	6	0	0
E S 36 × E S 26	3	1	0
E S 36 × S 47	5	0	0
Total	14	1	0

4 of the extracted Dutch bred together have so far given 10 young, all Dutch-marked. The matings were :—E D 53 × E D 37 gave 6 Dutch, and E D 54 × E D 41 gave 4 Dutch. 3 of the extracted marked individuals bred together and with hybrids gave 17 young, of which 3 were selfs, 12 were marked, and 2 were Dutch. The matings were :—E M 29 × M 10 gave 0 selfs, 4 marked, and 1 Dutch; E M 29 × E M 27 gave 1 self, 3 marked, and 1 Dutch; S 7 × E M 28 gave 2 selfs, 5 marked, and 0 Dutch.

The Appearance of the Dutch Markings.

The appearance of the true Dutch markings in the second generation of the marked line only was as interesting as it was unexpected, especially as there had been no Dutch-marked individual in the ancestry of either the original self-coloured Belgian or the white Angora for at least 8 generations, and probably many more. The fact that these Dutch-marked individuals appeared in about the proportion of one quarter, and bred true at once, was very significant. From the Mendelian point of view, the results pointed to the conclusion that No. 3 albino Angora gave off gametes carrying the factor for Dutch markings, and that these gametes, uniting with the pure self gametes of No. 4 self-coloured Belgian, gave rise to the slightly marked hybrids of the first generation. Ordinary Mendelian segregation apparently took place in the gametes of these intermediate hybrids, giving rise to gametes for self-colour and gametes for Dutch markings in about equal numbers, with the result that in the second generation there were one quarter pure self, one half hybrid marked, and one quarter pure Dutch. In order to test this conception experimentally, a pure self-coloured doe (No. 46) was mated with a pure Dutch buck (No. 51), giving 5 young all slightly marked with white, like the marked hybrids of the first generation between the original albino No. 3 and the self-coloured No. 4.

No. 3 albino was then mated with the same pure Dutch buck (No. 51), giving 11 young, all of which had the true Dutch markings; showing that this albino was indeed giving off gametes, carrying the factor for Dutch markings only.

The other albino No. 2 (which mated with the self-coloured No. 1 gave the self line) was mated with a pure Dutch-marked doe (No. 52, bred out of the same litter as No. 51), giving 5 young, all slightly marked with white, and none with the full Dutch markings ; showing that this albino was giving off gametes carrying the factor for self-colour only.

The above results go to show that pure-bred albinos carry the latent factors for self-colour and for Dutch markings.

The extracted albinos were also tested to some extent ; and, so far as the experiments go, it appears that they also carry the latent factors for self-colour and Dutch markings.

Thus in the self line, 3 extracted albinos, Nos. 14, 34, and 45,

so far as tested, appear to carry the self factor only, for mated with pure selfs they gave 16 young, all selfs, and mated with pure Dutch they gave 6 young, all slightly marked.

In the marked line, No. 39, extracted albino, appears to carry the self factor only, for mated with a pure Dutch it gave 10 young, all slightly marked; while the 2 extracted albinos, Nos. 15 and 16, appear to carry both the self and Dutch factors, for mated with pure selfs they gave 7 selfs and 3 slightly marked, and mated with pure Dutch they gave 10 Dutch and 9 marked.

So far as they go, therefore, the above results point to the following conclusions :—

(1) That both pure-bred and extracted albinos may carry the factors for self-colour and Dutch markings.

(2) Some of the albinos carry the self factor, others the Dutch factor only, and others, again, both the self and Dutch factors.

(3) The factors for coat-pattern remain latent when albinos are mated together, but become patent when the albinos are mated with normal individuals.

(4) The coat-pattern characters—unlike the previous characters dealt with—are neither dominant nor recessive towards one another, but when crossed give intermediate hybrids in the first generation. In the second and third generations, however, these characters appear to follow the ordinary Mendelian rules of segregation and gametic purity.

(5) The Dutch markings, which made their appearance in the second generation of the Belgian-Angora cross, appear to have been introduced by one of the albino Angoras (No. 3) and not the other (No. 2).

(6) The Dutch-marked rabbit would appear, therefore, to be a distinct mutation, rather than a partial albino caused by imperfect segregation. Similarly, the slightly marked forms are to be regarded as variable hybrids between the Dutch-marked and the self-coloured, rather than the result of varying imperfections of segregation from albinism.

These conclusions, arrived at from experiments with Rabbits, in some respects appear to be similar to those already obtained by Prof. Cuénot with Mice, while in other respects they seem to differ. Both results are in agreement so far, that the " panachure " in mice and the Dutch markings in rabbits are unit characters in heredity following the ordinary Mendelian rules of

segregation and gametic purity. Both agree, too, in the con-clusion that these factors appear to be carried by albinos in a latent state.

The "panachure" in mice, however, seems to differ from the Dutch markings in rabbits, in so far that it appears to be com-pletely recessive to self-colour or uniform coat; while, on the other hand, the Dutch markings, so far as observed, are neither recessive nor dominant to self-colour, giving variable hybrids, the majority of which have white markings tending towards Dutch markings. Occasionally, however, self-coloured hybrids appear, but, so far, no true Dutch-marked.

Another apparent difference between the "panachure" in mice and the Dutch markings in rabbits is that the latter seem to be more definite in character, with the pigment more localized than in the variable spotted mice. Further experiments with Dutch rabbits are now in progress in order to work out, if possible, some of these interesting details.

As will be seen from the list of references, the literature relating to the heredity of coat-colour in mice has been very extensive during the past two years, and space will not allow any detailed references to the important experiments of Cuénot, Darbishire, and Allen, and the valuable work of Bateson and Castle in the Mendelian interpretation of present and past records. Judging from my experience with rabbits, I am inclined to think that most, if not all, of the various complications and difficulties met with in the various experiments with mice may be interpreted by means of the simple Mendelian principles (bearing in mind the important results gained by Cuénot, in regard to the carrying of latent factors by albinos) without recourse to such interesting though complicated conceptions as mosaic gametes and resolution of compound characters.

SUMMARY.

Experiments in crossing Belgian rabbits with albino Angoras, and the subsequent interbreeding of the hybrids, have demon-strated the existence of 4 pairs of unit characters, viz. :—(1) Short and Angora coat ; (2) Normality and albinism ; (3) Grey and black coat ; (4) Self-colour and Dutch markings. Each of these pairs is inherited independently of the other, so that all kinds of combinations occur among the offspring (see Table 29, p. 320).

The first two pairs of unit characters, short and Angora coat, normality and albinism, have been fully investigated, and in their heredity are found to follow Mendel's original *Pisum* type in regard to dominance, segregation, and gametic purity.

Short and Angora coat.—The Angora coat is recessive to short coat in the first generation, segregates in Mendelian proportions in the second generation, and breeds true in the third generation, notwithstanding its dominant short-coated ancestry.

The short coat is dominant over Angora coat in the first generation, and segregates in Mendelian proportions into two breeding forms in the second generation—pure and hybrid.

The pure form breeds true in the third generation, notwithstanding its Angora ancestry, while the hybrid form gives a mixture of shorts and Angoras in Mendelian proportions. Owing to dominance, the pure and hybrid shorts are indistinguishable in appearance, and can only be determined definitely by experimental breeding.

Normality and Albinism.—Albinism is recessive to normality in the first generation, segregates in Mendelian proportions in the second generation, and breeds true in the third generation, notwithstanding its dominant normal ancestry.

Normality is dominant over albinism in the first generation, and segregates in Mendelian proportions into two breeding forms in the second generation—pure and hybrid.

The pure form breeds true in the third generation, notwithstanding its albino ancestry, while the hybrid form gives a mixture of normals and albinos in Mendelian proportions. Owing to dominance, the pure and hybrid normals are indistinguishable in appearance, and can only be determined definitely by experimental breeding.

The investigation of the two remaining pairs of unit characters, grey and black coat, self-colour and Dutch markings, is not yet completed. So far as the experiments go, however, the following results appear:—

Grey and black coat.—Black is recessive to grey in the first generation, segregates in Mendelian proportions in the second generation, and breeds true in the third generation, notwithstanding its grey ancestry.

Grey is dominant over black in the first generation, and appears to segregate into two breeding forms in the second generation—pure and hybrid.

The apparently pure grey has so far bred true in the third generation, but the numbers are not yet sufficient to test the matter definitely. The hybrid greys give a mixture of greys and blacks in Mendelian proportions. Owing to dominance, the pure and hybrid greys are indistinguishable in appearance, and can only be determined definitely by experimental breeding.

In regard to the greys, an interesting complication was observed. The original grey used was a pure yellow-grey, containing more yellow pigment and less black than the ordinary wild grey. The greys of the first, second, and third generations were all wild greys, and, so far, there has been no return to the original pure yellow-grey.

Self-colour and Dutch markings.—So far as the experiments go, these characters appear to be neither dominant nor recessive to one another, but give variable intermediate marked hybrids in the first generation. Segregation into the three forms in Mendelian proportions, however, takes place in the second generation, and, so far, the extracted self-coloured and Dutch-marked forms have bred true in the third generation, while the intermediate marked hybrids give the three forms again in accordance with the Mendelian principles.

Latent factors in Albinos.—With regard to simple albinism, albinos of any ancestry so far breed true, the factor for normality being apparently eliminated in accordance with the Mendelian principles.

With regard to characters other than albinism, *but compatible with it*, such as short and Angora coat, these are carried by albinos in either a patent or recessive state. With regard to characters other than albinism, *but incompatible with it*, such as grey and black coat, self-colour and Dutch markings, these are also apparently carried by albinos, but in a latent state only.

Grey and black coat.—Albinos of the same ancestry extracted from hybrid greys, containing recessive black, so far appear to be of two kinds, viz.:—albinos carrying black, and albinos carrying grey and black.

Pure-bred albinos, with all albino ancestors for at least eight generations, and probably many more, so far appear to be of the same two kinds.

Experiments have not yet been carried out to test whether certain albinos carry grey only.

Self-colour and Dutch markings.—Albinos extracted from self-coloured parents appear to carry the latent factor for self-colour only, while albinos extracted from marked hybrids containing the self and Dutch factors appear to be of two kinds, viz. :—albinos carrying self-colour, and albinos carrying self and Dutch.

Experiments have not yet been carried out to test whether extracted albinos carry Dutch only.

Pure-bred albinos with all albino ancestors for at least eight generations, and probably many more, so far appear to be of the three kinds, viz. :—albinos carrying self only, albinos carrying Dutch only, and albinos carrying both self and Dutch. All these latent factors for coat-colour and coat-pattern apparently carried by albinos do not become patent until the albino is bred with a normal or coloured form, presumably because they are incompatible with albinism. Nevertheless, in their latency, they appear to segregate gametically in albino matings as in normal matings, following the ordinary Mendelian rules of segregation and gametic purity.

These results confirm, and extend to rabbits, results already obtained by Prof. Cuénot in mice, though it would appear that the heredity of Dutch markings in rabbits differs in some respects from that of the " panachure " in mice.

Mendelian Analysis of individual Rabbits used in the Experiments.

The following table gives a list of 45 individual rabbits that have been analysed in these experiments in accordance with the Mendelian principles. First is given the Stud No. of the individual, the sex, the parentage, and the somatic characters somewhat abbreviated. Underneath is given the gametic constitution of the individual as determined in these experiments, the gametic factors being expressed in the same terms as the somatic characters above.

TABLE 29.

No. 1. ♀ (Pure Belgian) : Short, normal, grey, self.
        GAMETES : *Short, normal, grey, self.*

No. 2. ♂ (Pure Angora) : Angora, albino, white.
        GAMETES : *Angora, albino, black, self.*

No. 3. ♀ (Pure Angora) : Angora, albino, white.
        GAMETES : *Angora, albino, grey & black, Dutch.*

No. 4. ♂ (Pure Belgian) : Short, normal, grey, self.
        GAMETES : *Short, normal, grey, self.*

No. 5. ♀ (1 × 2) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal & albino, grey & black, self.*

No. 7. ♀ (3 × 4) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal & albino, grey, self & Dutch.*

No. 8. ♀ (3 × 4) : Short, normal, grey, marked.
        GAMETES : *Short & Angora, normal & albino, grey & black, self & Dutch.*

No. 9. ♀ (3 × 4) : Short, normal, grey, marked.
        GAMETES : *Short & Angora, normal & albino, grey & black, self & Dutch.*

No. 10. ♂ (3 × 4) : Short, normal, grey, marked.
        GAMETES : *Short & Angora, normal & albino, grey & black, self & Dutch.*

No. 11. ♀ (1 × 2) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal & albino, grey & black, self.*

No. 12. ♂ (1 × 2) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal & albino, grey & black, self.*

No. 14. ♂ (5 × 2) : Short, albino, white.
        GAMETES : *Short & Angora, albino, black, self.*

No. 15. ♀ (8 × 2) : Angora, albino, white.
        GAMETES : *Angora, albino, grey & black, self & Dutch.*

No. 16. ♀ (7 × 2) : Angora, albino, white.
        GAMETES : *Angora, albino, grey & black, self & Dutch.*

No. 17. ♀ (7 × 2) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal & albino, grey & black, self.*

No 18. ♀ (7 × 2) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal & albino, grey & black, self.*

No. **19.** ♀ (5 × 2) : Short, normal, black, self.
> GAMETES : *Short & Angora, normal & albino, black, self.*

No. **20.** ♀ (5 × 2) : Angora, normal, black, marked.
> GAMETES : *Angora, normal & albino, black, self.*

No. **21.** ♀ (5 × 2) : Short, normal, black, marked.
> GAMETES : *Short & Angora, normal & albino, black, self.*

No. **22.** ♀ (1 × 4) : Short, normal, grey, self.
> GAMETES : *Short, normal, grey, self.*

No. **23.** ♀ (3 × 2) : Angora, albino, white.
> GAMETES : *Angora, albino, grey & black, self & Dutch.*

No. **24.** ♂ (3 × 2) : Angora, albino, white.
> GAMETES : *Angora, albino, black, self & Dutch.*

No. **25.** ♂ (1 × 4) : Short, normal, grey, self.
> GAMETES : *Short, normal, grey, self.*

No. **26.** ♂ (11 × 12) : Angora, normal, grey, self.
> GAMETES : *Angora, normal & albino, grey & black, self.*

No. **27.** ♂ (9 × 10) : Short, normal, grey, marked.
> GAMETES : *Short & Angora, normal & albino, grey & black,*
> *self & Dutch.*

No. **28.** ♂ (9 × 10) : Short, normal, black, marked.
> GAMETES : *Short & Angora, normal, black, self & Dutch.*

No. **29.** ♀ (9 × 10) : Short, normal, grey, marked.
> GAMETES : *Short & Angora, normal & albino, grey & black,*
> *self & Dutch.*

No. **30.** ♀ (11 × 12) : Short, normal, grey, self.
> GAMETES : *Short, normal, grey & black, self.*

No. **31.** ♀ (11 × 12) : Short, normal, grey, self.
> GAMETES : *Short & Angora, normal & albino, grey & black,*
> *self.*

No. **32.** ♀ (11 × 12) : Short, normal, grey, self.
> GAMETES : *Short, normal, grey & black, self.*

No. **33.** ♀ (11 × 12) : Angora, normal, black, self.
> GAMETES : *Angora, normal & albino, black, self.*

No. **34.** ♀ (11 × 12) : Short, albino, white.
> GAMETES : *Short, albino, grey & black, self.*

No. **35.** ♀ (9 × 10) : Short, normal, grey, self.
> GAMETES : *Short & Angora, normal, grey & black, self.*

No. **36.** ♀ (9 × 10) : Short, normal, grey, self.
> GAMETES : *Short, normal & albino, grey, self.*

No. **37.** ♂ (7 × 10) : Angora, normal, grey, Dutch.
> GAMETES : *Angora, normal & albino, grey, Dutch.*

No. **38.** ♂ (7 × 10) : Short, albino, white.
        GAMETES : *Short, albino, grey & black, self.*

No. **39.** ♀ (7 × 10) : Short, albino, white.
        GAMETES : *Short & Angora, grey & black, self.*

No. **41.** ♂ (3 × 10) : Angora, normal, black, Dutch.
        GAMETES : *Angora, normal & albino, black, Dutch.*

No. **42.** ♀ (8 × 2) : Angora, normal, grey, self.
        GAMETES : *Angora, normal & albino, grey & black, self.*

No. **43.** ♀ (1 × 12) : Short, normal, grey, self.
        GAMETES : *Short, normal, grey, self.*

No. **44.** ♀ (1 × 12) : Short, normal, grey, self.
        GAMETES : *Short & Angora, normal, grey & black, self.*

No. **45.** ♀ (5 × 2) : Short, albino, white.
        GAMETES : *Short & Angora, albino, black, self.*

No. **50.** ♀ (Pure Angora) : Angora, albino, white.
        GAMETES : *Angora, albino, grey & black, self.*

No. **53.** ♀ (7 × 10) : Angora, normal, grey, Dutch.
        GAMETES : *Angora, normal & albino, grey, Dutch.*

No. **54.** (9 × 10) : Angora, normal, black, Dutch.
        GAMETES : *Angora, normal & albino, black, Dutch.*

CONCLUSIONS.

A study of the somatic characters and gametic factors of the
above individuals brings out the important fact that certain
individuals, identical in appearance and with precisely the same
ancestry, differ, in a regular and permanent manner, in their
breeding potentialities (*e. g.* Nos. 35 & 36).

In such cases it is evident that neither the outward appearance
of the individual nor a knowledge of its ancestry is a safe guide
to its breeding potentialities (it is only in the case of recessive
characters, of any ancestry, that the soma is a true guide), while,
on the other hand, as the above experiments show, a knowledge
of its gametic constitution and of the various dominances
provides a sure guide.

Once the gametic formula of each individual has been deter-
mined by Mendelian analysis, the future results of any matings
can be foreseen with accuracy, whereas a knowledge simply of
the somatic characters of an individual and its ancestors is
altogether unavailing.

The true measure of heredity therefore is neither the somatic

character of the individual nor of its ancestors, but its gametic constitution, and, in our present state of knowledge, this can only be determined by experimental breeding on Mendelian lines.

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POSTSCRIPT.

The Mendelian Principles of Heredity.

The classical experiments with Peas completed by Mendel in 1865 led him to the following conceptions of heredity [*].

[*] For English translation of Mendel's papers and further details see Bateson's 'Mendel's Principles of Heredity' (Cambridge University Press, 1902).

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A plant is composed of unit characters which are represented in the germ-cells, or gametes, by independent factors.

Pure breeding involves the union of *like* factors : (A × A = A A).

Cross breeding involves the union of *unlike* (but corresponding) factors : (A × B = A B).

Pure races give off gametes carrying the one factor concerned : (A A gives off A$_s$ simply).

Hybrid races give off two kinds of gametes, on the average in equal numbers, each carrying one of the factors concerned in the cross. *No gamete carries both* (A B gives off A$_s$ and B$_s$ in equal numbers, and no gamete carries A and B).

This is known as gametic segregation.

From this it follows that the offspring of the self-fertilized hybrids A B are of three kinds :—25 per cent. A A, 50 p. c. A B, and 25 p. c. B B.

The A A$_s$ and B B$_s$, being gametically pure, breed true notwithstanding their A B origin.

This is known as gametic purity.

The A B$_s$, being hybrids, breed as such, gametic segregation again taking place.

When more than one pair of unit characters are concerned in the cross, the average result can be calculated on the above basis by the simple calculus of chance.

In his experiments Mendel encountered the phenomenon of dominance, *i. e.* when certain pairs of unit characters were crossed, one of the pair was always dominant over the other, which Mendel termed recessive: A × B = A (B).

This dominance of A over B in the soma caused the offspring of the self-fertilized hybrids to appear as 3 A : 1 B. Analysis in the following generation, however, demonstrated their gametic formula to be 1 A A : 2 A B : 1 B B, in accordance with the Mendelian principles.   C. C. H.

28th February, 1905.

Zoological Nomenclature : International Rules and others.
By the Rev. T. R. R. STEBBING, M.A., F.R.S., Sec.L.S., F.Z.S.

[Read 2nd March, 1905.]

INDIVIDUALS and societies are sometimes accused of running counter to the laws of nature. In popular speech and writing this behaviour is regarded as immoral and worthy of punishment. Beyond doubt, the love of freedom or misliking of restraint exercises over some minds so powerful a fascination that they would, if they could, crumple up the laws of nature with exquisite zest. But that particular piece of mischief is out of man's reach. We have to be content with breaking domestic, æsthetic, linguistic, social, ethical, ecclesiastical, statutory, and international law. This protean mass, unlike the immutable laws of nature, is ever varying with time, place, and circumstance. Neither Medes nor Persians have contrived to make it in any one particular fixed and unalterable, so that we find in the course of history falsehood, theft, murder, parricide, not only practised, but justified and delighted in, as well as unselfishness, purity, truth, and filial affection.

On this occasion we are principally concerned with the linguistic department, but there is an international aspect of the question of no small importance, and there are some æsthetic and ethical points of view which are worthy of notice.

Within the last half-year four papers have appeared directly dealing with the subject, and written by persons whose position, opportunities, and acknowledged eminence must reasonably give them a commanding influence among their fellow zoologists. In order of appearance these papers are : first, " A Draft of Rules for Zoological Nomenclature, as basis for a revision of the International Rules of the International Nomenclature Commission," proposed by F. C. von Maehrenthal in Berlin (published in Braun's ' Zoologische Annalen,' vol. i. p. 89, Sept. 1904, Königsberg-i-Pr.); second, " Some Changes in Crustacean Nomenclature," by Mary J. Rathbun (in the ' Proceedings of the Biological Society of Washington,' vol. xvii. p. 169, December 1904); third, " International Rules of Zoological Nomenclature," by Professor Raphael Blanchard, Professor von Maehrenthal,

and Dr. C. W. Stiles, the introduction, in French, by Professor
Blanchard, being dated Berne, August 1904, but the whole paper
containing the rules themselves, in French, English, and German,
bearing as date of publication, Paris, 1905. Lastly, there is a
leaflet by Professor F. E. Schulze, dated Feb. 2, 1905, reporting
to the Academy of Berlin the progress of ' Das Tierreich' *,
and especially emphasizing the efforts made by the editorial
staff of that vast undertaking to secure the utmost possible unity
among zoologists on this much-discussed subject of nomenclature.

That these distinguished naturalists should turn aside from
their own special studies and occupations, concerned with things
and facts and the deeper mysteries of nature, to spend much
time and anxious thought in the endeavour to legislate about
names and questions of spelling, should raise a presumption that
the subject is in itself not wholly unimportant. In the ordinary
business of life, in order that men may meet one another by
appointment, in order that letters and parcels may reach their
intended destinations, we all appreciate and use the facilities
afforded by railway guides and postal directories. We all know
the confusion caused by having in the same kingdom a dozen
towns or villages called Walton, a dozen George Streets in the
same city, two John Smiths in the same terrace; the incon-
venience that arises when a long row of houses is re-numbered;
the risk of confounding Vienne and Vienna, Tonbridge in the
United States with Tonbridge in Kent; the difficulty of identi-
fying Mechlin with Malines, Trèves with Tries, Hafnia with
Copenhagen, or Constantinople with Stamboul. In common
life, however, the troubles that arise from these causes pinch us
but rarely. In systematic zoology it is different. Classification
has to deal with thousands and ten-thousands of species, every
one of which requires a distinctive designation. In making this
assertion I readily admit that you cannot get all human beings
to agree on any proposition whatever; but probably almost all
zoologists do think it desirable that every species of animal
should have a designation not shared by any other species of
animal, a designation valid for it and it alone in Tokio and
St. Petersburg, in Paris and Berlin, in Washington and London,
in Naples and Madrid, in Valparaiso and Melbourne—in short,

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* In this report the spelling of the name is changed without explanation to
' Das Thierreich.'

throughout the whole scientifically cultured world, without regard to race, political boundaries, or vernacular speech.

Then the question arises, how is this result to be attained? In his instructive, unassuming, and conciliatory preface to the trilingual international code, Professor Blanchard traces the history of the attempts that have been made to solve the problem. " Nomenclature," he says, " is the grammar of the natural sciences ; it was defined for the first time by Linnæus in the ' Philosophia botanica ' in 1751, and applied to begin with to the vegetable kingdom, not being introduced methodically into the animal kingdom by the celebrated Swedish naturalist until 1758." Since then, during the last sixty years, advisory rules or codes have been issued by Associations and Societies in different countries and with various aims. Some of these have not striven to control the whole field, but only special parts of it, as palæontology, ornithology, entomology. It is easy to understand that, when large departments of human learning are considered separately, regulations admirably fitted for one might not be equally applicable or convenient for them all. But the naturalist who begins his scientific life with the study of birds and butterflies can never be sure that either of those fascinating subjects will permanently secure his devotion. His affections may rove away in quite other directions, making him a student now of Protozoa and now of Primates, or onewhile a worshipper of earthworms and presently an authority upon whales. At any rate, whatever may be the varying requirements of individuals, it is the interest of the whole commonwealth of naturalists to have universal agreement as to the scientific names of the objects with which they are collectively concerned. Agreement is the principal thing, therefore get agreement. But to set the ships sailing from all quarters of the globe to capture this one position may not be easy. Each Agamemnon may have to sacrifice some darling Iphigenia if the whole fleet is ever to reach the point proposed.

The International Congress of Zoology, which held its first meeting in Paris in 1889, and has since then at triennial intervals met in Moscow, Leyden, Cambridge, Berlin, and Berne, from the very first took up this subject with the earnestness which it deserves, and is still handling it with commendable vigour and discretion. If this Congress is to be the legislative body for the future and our ultimate court of appeal on the

matter before us, it is desirable that we should clearly under-
stand the source of its authority, its methods of arriving at its
decisions, and therein especially the rights and opportunities
reserved for appellants under its truly imperial jurisdiction.
There is an old opinion that " General Councils may not be
gathered together without the commandment and will of Princes,"
and, further, that when they be gathered together they are still
liable to make mistakes. Among the men who have taken a
leading part in the International Congress of Zoology there are
many who might be rightly claimed as princes of science, and
none, I expect, who would wish to make any claim to being
infallible. So far, then, the authority, if in a large measure
self-constituted, has an origin and status with which English-
speaking people are not likely to find very much fault. On the
whole we think more of what is well done than of what is
logically done. Linnæus himself was a prince only by the divine
right of genius, and his system of nomenclature won acceptance,
not by act of parliament, but by virtue of sweet reasonableness.
In dealing with the Linnean system, it would have been a
courteous act, I think, to have invited the various Linnean
Societies spread over the globe, and especially the Linnean
Society of London, to take a prominent part. As things have
turned out, for reasons not very easy to comprehend, Great
Britain has been left in its favourite insular position, without
any practical voice in the latest proposals. There is, happily,
no need for any punctilious jealousy on this score, since it is
still open to us to offer whatever criticisms and recommendations
we please, with an excellent prospect of their commanding
respectful attention.

It has long been agreed—and may we not say very wisely
agreed?—that zoology and botany should be independent in
respect to generic names, so that a name will not be invalidated
in the one because it happens to have been earlier used in the
other. The double use of course is merely permitted, not
commended or recommended. The zoologist is not encouraged
to found a new genus *Rosa* for a camel or a skunk, when he has
good authority for believing that they would smell as sweet by
any other name. But apart from, or even including, this one
article of generic designation, would it not be convenient that
zoology and botany should have rules of nomenclature in common,
and should use the same symbols for identical purposes?

Nowhere can this question be more appropriately asked than before our Society, which not only in theory but in practice deals impartially with both these great branches of science. We turn from one to the other in the course of a single evening with facile versatility. Sometimes the two find common ground of report and argument. Not seldom one sheds interesting side-lights upon the other. Often by question and answer students of one draw forth from students of the other information and suggestions of value to both.

Professor Blanchard makes a frank and honourable appeal in behalf of the Commission over which he presides. "It is the right," he declares, "almost we might say the duty, of every zoologist to lay before us the difficulties which occur to him. The Commission is not a tribunal issuing absolute decrees, but a committee of philanthropic persons who have made a special study of the principles of nomenclature and have practical experience of the difficulties involved in their application. It examines impartially questions brought before it, seeking the most judicious solution of each problem in conformity with the standing rules, and submitting its answers with the reasons on which they are founded in a report to the International Congress, which then frames its decision in the light of full information." In spirit and expression nothing could be more to the purpose, and there is ground for thinking that the members of the Commission have made the most zealous endeavours to accomplish the impossible task of satisfying everyone. But there is a pregnant phrase in a recent biography of a statesman by a statesman, that "Agreement in principle is of little avail, without driving-force enough for practice" [*]. To secure this driving-force for practice in regard to the present subject seems to be far from a simple task. These comet-like zoological congresses, that make their dazzling brief appearance once in three years at different points of the scientific firmament, produce a very faint impression on naturalists who happen to be without inclination, means, health, or leisure for travelling, and on those who have no spare guineas to spend on miscellaneous Transactions. The several papers from Berlin and Paris, from Königsberg and Washington, brought under your notice as groundwork for this evening's discussion, may have been widely

* Morley's 'Life of Gladstone,' vol. ii. p. 398.

and liberally distributed. But that distribution is temporary, and almost of necessity limited to the persons who in a sense least need it—that is, to the persons known to be interested in the subject, who would therefore be almost sure to make themselves acquainted with essential items of its literature. Many will remember what happened with the Stricklandian Rules under the auspices of the British Association. They were left without any definite stamp of the issuing authority. They were allowed to go out of print. There was never any effort made in England, so far as I am aware, to impress upon beginners in zoology that any rules existed by which they might conveniently be guided. Editors in France were just as remiss. At least in one conspicuous instance they allowed a writer to load science with barbarous names as well as almost equally strange descriptions.

The Stricklandian Rules adopted the 12th edition of the 'Systema Naturæ,' which began its publication in 1766, as the starting-point for modern zoological nomenclature. The International Rules accept the 10th edition of the 'Systema,' and January 1st, 1758, as epoch-making for the same purpose. Might it not be better, even now, to fix the beginning of the new era in 1751? This would put the dividing-line in the exact middle of the eighteenth century. It would give the 'Philosophia botanica' its due acknowledgment as the leader in a great reform. It would bring into line at least one important work on zoology, Clerck's 'Aranei Suecici,' in which the binomial usage was followed prior to 1758. This last consideration is by no means trivial, for it seems inexcusably ungenerous and improper to set up a standard of nomenclature, and then to invalidate names used in accord with that standard, only because they were published before an arbitrary date. I urge this in spite of a small personal interest which I have in upholding the year 1758, because that is the year in which Borlase published 'The Natural History of Cornwall.' More than once I have maintained that *Astacus* is the proper generic name for the common English lobster. Now Borlase at page 274 of the work just mentioned, after speaking of what he calls the Long Oyster (the *Locusta marina* of Aldrovandi), distinguishes from it "the lobster, or *Astacus verus*, much superior in delicacy of food to the former, and in such plenty on the coasts of Cornwall, that Well-boats come to load, and

carry them to London and elsewhere." From this account there can be no doubt of the species intended. Accordingly the Cornish naturalist, as if with a prophetic eye to future controversy, at the earliest available moment here distinctively proclaims *Astacus* to be the genus of the common lobster, writing as he does in and concerning a county in which the rival claimant, the river crayfish, neither then nor now was ever known to occur. This is only an *argumentum ad hominem*. But it should be conclusive with those who think that, when any large loosely defined genus is eventually broken up into several genera, the original name is bound to go with that species which was first mentioned separately as a member of the genus.

A genus may be founded for a single species, and from that species, as long as the genus stands, it can never be separated. But a genus may be founded for a dozen species, no two of which in process of time are allowed to stand under the same generic name. Then the nice Sadducean question arises, which of the twelve has a right to the name of the original genus, once enjoyed by them all in common? A species indicated by the author as typical has the best claim. A species indicated by him as doubtful has no claim at all. But in old obscurely defined genera these helps are rarely at our command. We must then have recourse to Article 30 of the International code, which provides that, " If the original type of a genus was not indicated, the author who first subdivides the genus may apply the name of the original genus to such restricted genus or subgenus as may be judged advisable, and such assignment is not subject to subsequent change." To this rule are appended certain cautions and useful recommendations. But neither the precision of the rule nor Dr. von Maehrenthal's elaborate comment seems to meet all the problems which ingenuity and research have recently evolved. One might innocently suppose that the author who first subdivides a genus is the author who first subdivides it, and that no more need be said. But in so supposing one is likely to find oneself egregiously mistaken.

To make the matter intelligible, it will be necessary for me to tax your patience by bringing forward concrete examples. You will excuse my taking them from the branch of zoology with which I am most conversant. Do not think it unchivalrous

that on this point I challenge the opinions of a friend, an absentee, a lady. As a matter of fact, Miss Mary J. Rathbun, of the National Museum in the United States of America, if not the foremost living authority on the higher Crustacea, may be held to have in this department of knowledge no living and working superior, and probably no equal except in Major Alcock, a Fellow of our own Society. It is this very pre-eminence on her part that makes it a matter almost of urgency that we should come to an early understanding on the rules of nomenclature with a writer so accurate and copious, so full of knowledge and so deservedly influential as Miss Rathbun. Already no little entanglement has been introduced into synonymy by her acceptance of Latreille's Manual of the Arthropoda *, published in 1810, as a sort of bed-rock for generic subdivision. This book gave a conspectus of genera, many of them defined in the briefest and crudest manner, and concluded with a list in which, as a rule, the name of each genus was accompanied by that of a single species. In the view of Miss Rathbun, this catalogue sealed the fate of all those genera that were open to subdivision, although there was certainly and obviously no intention on Latreille's part to subdivide them. Supposing that he had intended to do so, is it to be conceded that an author may select the type of another man's genus without explaining why he selects it, or whether he has any reason for considering the rest of the species less typical than his chosen type? This matter has been argued elsewhere †. We may pass on to consider a still more startling step in the same direction, announced in the 'Proceedings of the Biological Society of Washington' for December 1904. Therein Miss Rathbun explains that she has become acquainted with Weber's 'Nomenclator entomologicus' ‡, published in 1795; that "under the Agonata or Crustacea, pp. 91–96, many of the genera first described in J. C. Fabricius's 'Supple-

* Considérations générales sur l'ordre naturel des animaux composant les classes des Crustacés, des Arachnides, et des Insectes; avec un tableau méthodique des leurs genres, disposés en familles. Paris, 1810.

† "The late lamented Latreille. A Study in Names." Natural Science, vol. xii. p. 239 (1898).

‡ Nomenclator entomologicus, secundum Entomologiam systematicam illustr. Fabricii, adjectis speciebus recens detectis et varietatibus conscriptus a Friderico Weber Chiloniensi. Chilonii et Hamburgii, 1795.

mentum Entomologiæ Systematicæ,' 1798, are enumerated, and
as they are accompanied by lists of species most of which were
previously known, the genera themselves must date from 1795
instead of 1798." She adds that " this has already been brought
out by Sherborn in his ' Index Animalium,' 1902."

When Weber's book itself is examined, it seems to be the
most extraordinary ground that ever was taken for throwing
synonymy into needless confusion. In his preface he makes
this statement :—" The discerning naturalist Daldorf will shortly
publish a very important work on the Agonata. Meantime in
this Nomenclator I have so named and denoted them, as the
celebrated Fabricius will hereafter accept them. But more
distinct characters of these genera will be set forth in the book
presently to be published by Daldorf." Further on he says :—
" In these Agonata you will find a quantity of new species.
With these and others, which Fabricius, since the publication of
his ' Entomologia Systematica,' has newly described, and will
by and bye publish in the form of a supplement, he has been
pleased to supply me, whereby the Nomenclator has been
augmented with many new species." Weber's catalogue, it may
be said, is confessedly the work of a busybody. He was allowed
freely to examine the collections of his friends Fabricius and
Daldorf. From them he borrowed provisional manuscript names
of genera and species, and hastened to inform the world that such
and such systematic and nominal changes were about to be
adopted by his distinguished friends. Does this prediction,
which in several instances was falsified by the event, attach any
status or disability to those undefined generic names about which
his false prophecies were made ? In 1801, when Weber wrote
on genera of insects which he had himself established *, he
makes no claim or allusion to any genus of the Agonata. It
would have been strange indeed, in a work which he dedicates to
Fabricius with the most affectionate expressions, had he claimed
genera which could only have been his by a scandalous theft
from his much-eulogized friend. In the Index to the ' Entomo-
logia Systematica,' published in 1796, there is a half contemptuous
footnote-reference to the ' Nomenclator.' The Index itself
mentions the new generic names about to be used in the ' Sup-

* ' Friderici Weberi Soc. phys. Ienens. adscr. Observationes entomologicæ,
continentes novorum quæ condidit generum characteres, et nuper detectarum
specierum descriptiones.' Kiliæ, MDCCCI.

plementum,' but merely as a civil invitation to other naturalists not to interfere with them—a very superfluous precaution if they had been already preoccupied by Weber. When the 'Supplementum' was published in 1798, it took no notice whatever of Weber's unauthorized programme. Miss Rathbun now wishes to re-introduce it as a dominant though very confounding force in carcinology. Are we to accept the ruling that a genus will be well founded if an author publishes the simple statement that another author proposes at some future time to use such and such a generic name for such and such previously-known species? By answering yes, you would, I conceive, put a weapon into the hands of idle, ignorant, mischievous persons who might soon make you regret the response.

But the rejection of Weber's catalogue as valueless still leaves open for consideration a point of some importance. It has, in fact, been hitherto the privilege of naturalists, in separating a species of which the distinctive characters are known, to establish a new genus for it by simply referring to the work in which those distinctive characters have been already published. They practically become the definition of the new genus, merely being raised from specific to generic value. But this privilege, more conducive to slovenliness in authors than to contentment in their students, is open to great abuse, should the new genus be created not for one or two species but for a considerable number. Would it not be well that the privilege should be strictly defined or cancelled—for the future?

In the last proposal stress is laid on the words "for the future." We cannot come to an agreement with posterity. We cannot bind our successors. But by equity towards the past we may win some title to equity from the future. Now, in the early Linnean time, as you know, one generic name often covered an enormous number of species. The genus *Cancer,* for example, included all the crabs and lobsters and shrimps and some other things, which are now dispersed over hundreds of genera in several orders and numerous families. When the necessary breaking up of an unwieldy genus began, it was a common practice, in endowing a particular species with separate generic rank, to adopt its specific name for the new genus and to bestow upon the species itself a new specific name. Thus the common shrimp, *Cancer crangon,* Linnæus, became *Crangon vulgaris,* Fabricius. When this was done, there was no rule against doing it. But

now the rule is set up that the old specific name must be restored, so that the species will be *Crangon crangon* (Linn.). Coupling this determination with new rules about subgenera and subspecies, it is apparently possible to have a creature called *Apus* (*Apus*) *apus apus*, which seems to me calculated to bring nomenclature into contempt. The equitable plan would be to accept the terminology which our scientific ancestors employed in *Crangon vulgaris* and the like, while ruling that *in future* specific names are to be left in their places and not transferred to a higher grade. This is not setting aside the essential law of priority, but upholding in the interest both of equity and euphony what our predecessors did, when they had a perfect right to do it, against *ex post facto* legislation.

Some points more easy to follow in print than in speech are relegated to an appendix. My main argument has been directed to enforcing upon your attention the overwhelming importance of agreement, the difficulties in the way of arriving at it, the desirability of keeping naturalists in touch with the best conclusions, and, finally, the claim which the subject of scientific nomenclature in its broadest aspects has upon the interest of this Society. None have a better right, none have a higher duty than ourselves to work for the improvement of the Linnean code till it wins the consent of naturalists in general as the best and most polished instrument of its kind for the advancement of science.

APPENDIX ON POINTS OF DETAIL.

1. To signify that a specific name is combined with a generic name other than that with which it was originally published, might not botanists and zoologists agree to have a method of notation in common ?

2. To simplify synonymy, it is suggested that all new generic names of animals should be regarded as of the masculine gender. It is no essential part of natural history to discover that *Melicerta* is masculine, *Ino* feminine, *Callisoma* neuter ; that *planus* and *plana* are adjectives, but *nanus* and *nana* substantives ; or that you may say *longimana*, to signify long-handed, although *mana* in Latin means, not a hand, but a goddess or a sponge.

3. In regard to generic and specific names of more than two syllables, it would be a boon, at least to English-speaking

people, to have the proper pronunciation indicated by some accentual mark, as *Chenalópex*, *Callisóma*, *Rhizóstoma*. The use of the letter *k* in such names as *Ancístrodon* and *Cárcinus* is rather to be commended than deprecated. In the transcription of other Greek words the use of the letter *h* to represent the aspirate may be desired but should not be enforced, and the representation of the diphthongs ει and ου by the same letters in the Latin alphabet, if not enforced, should at least be legalised. A rule which leads to such a form as *Möbiusi*, and which rests apparently on a distinction between Latin down to the close of the eighteenth century and later Latin, carries its own condemnation.

4. The common practice of printing generic and specific names in italics is open to the objections that this character is less easy to read than Roman type and does not wear so well. It is suggested that some other distinctive type, which is not open to these objections, should be recommended.

5. A recommendation following article 36 of the International Rules implies that *caeruleus* and *coeruleus*, *silvestris* and *sylvestris*, *littoralis* and *litoralis*, *autumnalis* and *auctumnalis* may be held valid for pairs of species in the same genus. That would be very objectionable, seeing that these are only alternative spellings of the very same words, not at all comparable with such pairs as *fluvialis* and *fluviaticus*, *sinensis* and *sinicus*, *ceylonicus* and *zeylonicus*, words of the same meaning but perfectly distinct formation.

6. In reference to article 21 of the International Rules, the question arises whether for the future some rule might be formulated by which an author's claim to priority for new names of genera and species should rest, not unconditionally on date of publication, but on the date of reasonable publication. In 1885 Sarato published a new genus and species *Ligur Edwardsii* in 'Le Moniteur des Étrangers,' a weekly journal at Nice (see Senna, Bull. Soc. Ent. Ital. vol. xxxiv. p. 319, 1903). But, apart from scientific work published in an unsuitable medium, the rule in giving validity to a name published " in connection with an indication " seems vague and open to abuse by ignorant or even mischievous persons.

Revision of the European Marine Forms of the *Cirolaninæ*, a
 Subfamily of Crustacea Isopoda.   By H. J. HANSEN,
 Ph.D., F.M.L.S.

[Read 2nd February, 1905.]

(PLATES **33–35**.)

IN 1890 I published a paper entitled " Cirolanidæ et familiæ
nonnullæ propinquæ Musei Hauniensis " (K. Danske Vidensk.
Selsk. Skrifter, 6. Række, naturv. og mathem. Afdeling, B. v.
pp. 239–426, tab. 1–10).   The material preserved in the
Copenhagen Museum was comparatively rich; from Europe
and the West Indies especially it possessed a large number of
species.   I was therefore able to prepare the treatise as a kind
of monograph : all forms available were described ; a list of all
genera and species unknown to me, with all localities mentioned
in the literature of the subject, was put together, and an attempt
was made to refer such animals to the genera or families to
which they really belonged * ; the paper contains also a rather
detailed representation of the appendages, especially of the
mouth-parts.   These particulars are mentioned here because
in the following treatise that paper is taken as the starting-
point.   I have nothing to add to my earlier investigation of the
mouth-parts and other appendages, the antennæ excepted ;
further, the reader is referred to the numerous figures of several
species and to the detailed account of biology, earlier synonymy,
&c., given in that paper, but omitted here in order to avoid
unnecessary reprinting of these portions.

Since 1890 many authors, viz., J. Bonnier, A. Dollfus, P. Gourret,
H. J. Hansen, S. Lo Bianco, G. O. Sars, T. Scott, T. R. R. Stebbing,
and A. O. Walker, have published papers containing contributions
to our knowledge of the European marine forms of the group ;
several new species have been established, and especially numerous
new localities for earlier known species have been enumerated.
These treatises are registered in the " List of Papers " (p. 370),
and an abstract of their contents is given under the species in
question, but two of them must, nevertheless, be mentioned here.
In the paper "Isopoden, Cumaceen und Stomatopoden der

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* Several of the descriptions are unfortunately so imperfect that I could only
doubtfully locate the various forms.

Plankton-Expedition," 1895, I attempted tentatively to procure equivalence between the families of the order Isopoda ; the family Cymothoidæ sens. lat. was established as equivalent with Sphæro- midæ, Bopyridæ, or Epicaridæ, &c. ; the six families Cirolanidæ, Corallanidæ, Alcironidæ, Barybrotidæ, Ægidæ, and Cymothoidæ, accepted or established by me in 1890 in the above-named paper, were now considered as subfamilies (*Cirolaninæ*, &c.) of he family Cymothoidæ. This explains the use of the name *Cirolaninæ* in the title of the present treatise. In 1903 A. Dollfus published " Note préliminaire sur les espèces du genre *Cirolana* . . . . de l'Hirondelle et de la Princesse-Alice " (Bull. Soc. Zool. France, vol. xxviii. pp. 5–10) ; the author describes a new deep-sea species from the Mediterranean, and enumerates numerous new localities for some other species.

In 1902 my friend, the Rev. Canon A. M. Norman, urged me to work out some *Cirolaninæ* preserved in his splendid collection of European marine Invertebrates, among which was *Eurydice polydendrica*, Norm. & Stebb., published as a *nomen nudum* many years ago : I promised to do so. In 1890, M. A. Dollfus sent me a considerable number of French *Cirolaninæ*, among which I found one new species of *Eurydice.* Then I resolved to write a revision of the European marine species. In order to get more material, I applied to Professor Yves Delage, who kindly forwarded a vast number of *Conilera cylindracea* and of a species of *Cirolana* which, to my great astonishment, proved to be a new form. I beg these three gentlemen to accept my sincere thanks. Finally, I inserted the material received by the Copenhagen Museum since 1890 from various sources.

As stated in the title, the aim of the present treatise is to give a revision of the European marine forms of the subfamily, while the freshwater forms found in France are omitted from want of material. Before 1890 six valid species had been described (the rather doubtful *Eurydice pontica*, Czern., not included) ; in 1890 I added three species, and since that year three valid species have been found or described. The total was thus 12 species. In the present paper I add three more species ; so that the total is now 15 species, belonging to the three genera *Cirolana, Coni- lera*, and *Eurydice*, all established by Leach. Of *Eurydice* only two species, viz. *E. pulchra*, Leach, and the female of *E. trun- cata*, Norm., were known before 1890 ; I am now able to enumerate six European species. But these species, though

exhibiting excellent specific characters, are closely allied and so similar in general aspect, size, and colour, that authors have certainly often committed mistakes in naming their material; for this reason I think that at least some of the statements in the literature on the occurrence of the species, especially *E. pulchra*, are erroneous and misleading. Furthermore, the discovery of a new and large species of *Cirolana* in abundance on the northern coast of France, and closely allied to *C. borealis*, proves *that great caution is necessary in determining species of this group*. In the following account I shall endeavour to distinguish as well as possible between trustworthy and doubtful statements as to localities, but where no description or figures are given it is, of course, only a kind of calculation of probabilities, and even a gross error may readily escape discovery.

Conspectus of the Genera *.

A. Peduncle of antennæ with at least five very distinct, movable joints†. Lobe from second joint of the maxillipeds furnished with one hook or two or three hooks. Peduncle of uropods produced considerably or much backwards, so that the articulation between peduncle and endopod is rather long.

   a. First and second pairs of pleopoda subsimilar, with the endopod submembranaceous; peduncle of first pair much broader than long .... I. CIROLANA, Leach.

   b. First pair of pleopoda very firmly chitinized everywhere, constituting a large operculum, with the peduncle longer than broad and the inner branch elongate; second pair of pleopoda with both rami submembranaceous and the peduncle broader than long .... II. CONILERA, Leach.

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* This key is in the main only a translation of the Latin conspectus in my monograph.

† In 1890 I described and figured five joints in the peduncle of the antennæ in *Cirolana*. In the paper, "The Deep-sea Isopod *Anuropus branchiatus*, Bedd., and some Remarks on *Bathynomus giganteus*, A. M.-Edw." (Journ. Linn. Soc., Zool. vol. xxix. pp. 12–25, 1903), I showed that this peduncle in *Bathynomus giganteus* consists of six movable joints. Having found the basal joint hitherto overlooked in this animal, I was able to point out the same joint in *Cirolana borealis* and *C. Cranchii*: the joint is distinct, situated at the outer margin of the joint hitherto considered as the first, but it is not easy to catch sight of; it is probably found in all species of *Cirolana*, and I have besides observed it in *Conilera*. The mode of expression in the conspectus is chosen for practical reasons.

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B. Peduncle of antennæ with only four distinct joints.
　　Lobe from second joint of the maxillipeds without
　　hooks *.　　Peduncle of uropods slightly produced
　　backwards, and the articulation between peduncle and
　　inner branch short .... III. EURYDICE, Leach.

I. CIROLANA, *Leach.*

The characters of the genus are given in the conspectus of the
genera.

Conspectus of the Species.

A. Frontal plate elongate, at least nearly three times
　　longer than broad. Three posterior pairs and especially
　　seventh pair of thoracic legs with many long plumose
　　natatory setæ.
　　a. Eyes very distinct, generally brownish or black, but
　　　　if colourless the facetting is seen.
　　　　α. Seventh thoracic legs have the second joint †
　　　　　　strongly flattened and expanded, at most only
　　　　　　twice as long as broad, with a close row of long
　　　　　　natatory setæ along the outer margin ; fourth
　　　　　　joint not longer than sixth.
　　　　　　§ Major portion of upper margin of the eyes straight.
　　　　　　　　Four posterior pairs of thoracic epimera com-
　　　　　　　　pletely without oblique ridge or furrow—only
　　　　　　　　with the usual furrow along the lower
　　　　　　　　margin .... 1. *C. borealis,* Lilljeb.

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* This character, which may be considered interesting, was pointed out by
me in 1890. G. O. Sars gives in his ' Crustacea of Norway,' vol. ii. pl. 30.
fig. 2 *mp.,* a drawing of the left maxilliped of *Eurydice pulchra,* on the lobe
from the second joint of the maxillipeds two small hooks are shown ; but I have
re-examined the maxillipeds of this species, and can repeat my earlier state-
ment that such hooks do not exist. In the text (p. 73) Sars writes only :
" Oral parts on the whole resembling those in *Cirolana.*" In the description
of the genus *Cirolana* he says that the lobe mentioned has " 2 curved hooks
inside," but in *C. borealis* I had found and figured three hooks, and also stated
(Cirolanidæ &c. p. 278) that in this genus the number varied from one to
three. Moreover, Sars ought to have added that his figure represented the
maxilliped of an ovigerous female, the large plate from the second joint being
wanting in the male. Finally, it may be mentioned that he has overlooked the
second of the two best characters for the genus *Eurydice,* viz., that the peduncle
of the antennæ is four-jointed. If that highly talented and most meritorious
author would use the literature somewhat better than he frequently does, he
would avoid several errors, &c.

† The " epimera " on the second to seventh thoracic segments here and in
the following descriptions counted as the first joint of the legs.

§§ Upper margin of eyes convex. Four posterior
    pairs of thoracic epimera each with a con-
    spicuous oblique furrow besides the furrow
    along the lower margin.
    † Eyes black. Seventh thoracic legs closely set
      with natatory setæ along the whole inner
      margin of second joint. Hind margin of last
      abdominal segment with only two pairs of
      spines. Endopod of uropods somewhat more
      than two and a half times as long as broad.
                          2. *C. gallica*, n. sp.

    †† Eyes light brownish or colourless. Seventh
      thoracic legs without setæ along the major
      portion of inner margin of second joint.
      Hind margin of last abdominal segment with
      five or six pairs of spines. Endopod of uro-
      pods slightly more than twice as long as
      broad...................... 3. *C. neglecta*, H. J. H.
β. Seventh thoracic legs have the second joint about
    three and a half times as long as broad, and on
    its outer margin only a few short setæ; fourth
    joint much longer than sixth........ 6. *C. microphthalma*,
                                         Hoek.
b. No eyes.
    a. All six pairs of thoracic epimera with the oblique
      furrows well developed .... 4. *C. Schmidtii*, n. sp.
    β. All six pairs of thoracic epimera without furrows.
                             5. *C. cæca*, Dollf.

B. Frontal plate at most half as long again as broad. Three
    posterior pairs of thoracic legs without natatory setæ,
    or at most with a few plumose setæ at the outer
    margin of second joint.
    a. Frontal plate small, not visible from above, its lower
      surface without any impressed area. Clypeus
      without any free process. Eyes rather large.
                         7. *C. Cranchii*, Leach.

    b. Frontal plate very large, its front end visible from
      above; its lower surface with a large oblong
      impressed area. Clypeus protruding freely in
      front as a nearly lamellar process. Eyes small.
                     8. *C. Hanseni*, Bonn.

Group A.

Frontal plate elongate, at least nearly three times longer than broad. Three posterior pairs and especially seventh pair of thoracic legs with a great number of long plumose natatory setæ.

1. CIROLANA BOREALIS, *Lilljeborg* (1852).
1890. *Cirolana borealis*, H. J. Hansen, Cirolanidæ, &c., p. 321, pl. i. figs. 1–1 *v* (with synonymy).
1897. *Cirolana borealis*, G. O. Sars, Crust. of Norway, vol. ii. p. 70, pl. 29.

Eyes blackish, seen from the side somewhat longer than deep, with the major portion of the upper margin straight.

Frontal plate about three times longer than broad ; its front end not visible from above. Clypeus without anterior process ; its surface feebly convex, with a deep furrow along each lateral margin.

Antennulæ considerably shorter than the peduncle of the antennæ ; flagellum consists of numerous very short joints.

Antennæ reach almost or about to the middle of thorax ; flagellum with numerous (about thirty) joints.

Epimera of second and third thoracic segments with a short rudiment of an impressed line besides the submarginal furrow ; epimera of fourth to seventh segments without any furrow or ridge besides the submarginal one ; epimera of seventh segment somewhat smaller than those of the sixth.

Seventh thoracic legs have second joint strongly flattened and expanded, somewhat less than twice as long as broad, with both lateral margins and the longitudinal ridge along the middle of the lower side very closely set along their whole length with long plumose setæ. Fourth joint scarcely longer than fifth and somewhat shorter than sixth.

Last abdominal segment with the lateral margins convex, not angular at the beginning of the terminal third ; this distal part with about four pairs of marginal spines ; the tip moderately angular, scarcely acute.

Uropoda slender. The endopod, which, when directed parallel with the axis of the animal, reaches somewhat beyond the end of abdomen, is somewhat more than two and a half but not fully three times longer than broad, without notch at the end of the outer margin. Exopod at least four times longer than broad and considerably shorter than the endopod, with about four spines along the outer margin.

Length 27–33 mm.

Occurrence.—In 1890 I gave a detailed criticism of the synonymical confusion and full account of the localities, dividing these into two portions: one comprising those which are certain or at least highly probable, the other portion including a number of doubtful statements.   Since 1890 Dollfus has published some localities of importance, but otherwise little has been added to our knowledge.   In Mr. Dollfus's collection I have found material from some new places: Belle-Isle (off the south-western coast of Brittany), 60 and 100 metres; Firth of Clyde; and Villefranche.   Further, I have seen nine specimens taken on bait on long-lines in lat. 61° 6′ N., long. 9° 21′ W., 210 fathoms, cruise of ' Michael Sars ' in 1902 (Cand. mag. Ad. Jensen.).   Probably some of the localities in North-western France and Southern England mentioned in the literature refer in reality not to this, but to the following species. The specimens from the Adriatic referred by Heller, Stalio, and Stossich to *C. hirtipes*, M.-Edw., and mentioned with much doubt by me in 1890, probably belong to *C. neglecta*, H. J. Hansen ; the specimen from Mr. Krupp's collection, mentioned by Lo Bianco in 1902 (Mitt. Zool. Stat. Neap. xvi. p. 258) as *C. hirtipes*, is probably *C. borealis*.

Our present knowledge may be summed up as follows.   The species has been taken in various places in the Kattegat, 13–29 fathoms ; along the southern and western coasts of Norway " at least to the Trondhjem Fjord " (G. O. Sars) ; in lat. 64° 48′ N., long. 6° 32′ E. (G. O. Sars) ; Shetland Isles (Norman) ; several places on the coasts of Scotland and Ireland (various authors); on the northern part of the western coast of France ; in the Mediterranean at Villefranche, and at Naples, 25 fathoms (Hansen), and, according to Dollfus, in various places in the western half of that sea at depths ranging from 280 to 1210 metres.   It has also been found off the eastern coast of North America between lat. 32° and 33° N., long. $77\frac{1}{3}°$ and $78\frac{2}{3}°$ W., 233 and 229 fathoms (Harger) ; finally, according to Miss Richardson, " off Cape Florida," but this statement is, in my opinion, rather doubtful and needs confirmation.

Remarks.—This species is easily distinguished from all other forms hitherto known by the characters pointed out in the eyes, epimera, seventh thoracic legs, uropoda, and armature of last abdominal segment.

2. CIROLANA GALLICA, n. sp.   (Pl. **33**. figs. 1 *a*–1 *d*.)

Eyes black, seen from the side slightly or scarcely longer than deep, with the upper margin rather convex.

Frontal plate, clypeus, and antennulæ much as in *C. borealis*.

Antennæ shorter than in the preceding species, reaching almost to second thoracic segment ; flagellum with about twenty-two joints.

Epimera of second and third thoracic segments with a long, slightly curved, and somewhat oblique furrow besides the submarginal one ; epimera of fourth to seventh segments shaped as in *C. borealis*, but furnished with a very oblique furrow which on fourth to sixth, not on last segment, reaches to their posterior margin.

Seventh thoracic legs have the second joint strongly flattened and extremely expanded, nearly two-thirds as broad as long, with both lateral margins and the longitudinal ridge on the lower side very closely set along their whole length with long plumose setæ.   Fourth joint very conspicuously longer than the fifth and slightly shorter than sixth.

Last abdominal segment with the lateral margins convex, not angular at the beginning of the terminal third ; only two pairs of spines on the distal margin ; the end is sharply angular.

Uropoda slender.   The endopod, which, when parallel with the axis of the animal, reaches a little beyond the end of abdomen, is somewhat more than two and a half but not fully three times as long as broad, without distinct notch near the end of the outer margin.   Exopod at least four times longer than broad and considerably shorter than the endopod, with a few (two or three) spines along the outer margin.

Length :—One of the largest specimens, a male, measures 20 mm., but whether the animal is really adult or not cannot be settled.   Female with marsupium unknown.

Occurrence.—Roscoff, or perhaps Guernsey or Jersey.   A large number of specimens belonging to the maritime station of Roscoff have been kindly sent to me by Professor Yves Delage.

Remarks.—This species is rather closely allied to *C. borealis*, but it is easily distinguished by a number of characters, among which those used in the conspectus are very easily observed. *C. gallica* has in all probability been seen before now and confounded with *C. borealis*.   I think it very likely that it will be found on the southern coasts of England and Ireland, and on the western coasts of France, Spain, and Portugal.

3. CIROLANA NEGLECTA, *H. J. Hansen* (1890).

1890. *Cirolana neglecta*, H. J. Hansen, Cirolanidæ, &c., p. 327, pl. i.
figs. 3–3 *i*; pl. ii. figs. 1–1 *b*.
1903. *Cirolana neglecta*, A. Dollfus, Bull. Soc. Zool. France, vol. xxviii.
p. 7.

Eyes light brown (or colourless, according to Dollfus); seen
from the side a little shorter than deep, with the upper margin
strongly convex.

Frontal plate, clypeus, and antennulæ differ slightly from the
same parts in *C. borealis*; antennulæ, however, somewhat less
robust, with the flagellum proportionately a little longer.

Antennæ reach almost to the middle of thorax; flagellum
with about twenty-two joints.

Epimera of the thoracic segments shaped and furrowed nearly
as in *C. gallica*, but the furrows are deeper; seventh epimera
somewhat larger and more produced than in that species, but
yet shorter than the sixth, with its oblique furrow extending to
the posterior margin.

Seventh thoracic legs have the second joint strongly flattened
and expanded, a little less than twice as long as broad; its outer
lateral margin and the longitudinal ridge on the lower side
closely set along their whole length with plumose setæ, which
are long on the margin, much shorter on the ridge; while the
major portion of its inner margin is naked, and very long
plumose hairs are found along its most distal, strongly rounded
part. Fourth joint is slightly shorter than fifth and very
conspicuously shorter than sixth.

Last abdominal segment with the proximal two-thirds of the
lateral margins slightly convex, the terminal third more oblique
and forming a very obtuse angle with the proximal portion;
the terminal third is armed with about five pairs of marginal
spines; the end is conspicuously angular.

Uropoda conspicuously broader than in the two preceding
species. Endopod, which reaches slightly beyond the abdomen,
is slightly more than twice as long as broad, without any notch
at the end of the outer margin. Exopod not fully three times as
long as broad and considerably shorter than the endopod, with
several spines at the outer margins.

Length 12–15 mm.

Occurrence.—The species was established on specimens from
Naples and a specimen probably from Nice; some of the

specimens from Naples were taken in a depth of about 25 fathoms together with *C. borealis.* In material received from Mr. Dollfus was found a large number of specimens from Le Croisic (south-western coast of Brittany), captured by E. Chevreux, and some specimens from Villefranche. The specimens from the Adriatic wrongly referred to *C. hirtipes,* H. M.-Edw., by Heller, Stalio, and Stossich, belong in all probability to *C. neglecta.* Dollfus enumerates (*l. c.*) nine stations in the western part of the Atlantic; one of these is near Belle-Isle (not very far from the south-western coast of Brittany), 19 m., while the remaining eight stations are between lat. 39° 18′ N. and lat. 30° 1½′ N., with depths from 1007 down to 1924 m.; finally, he has seen specimens from the Bay of Giardini, Sicily, 16 m., and from the Adriatic. Dollfus states that the pigmentation of the eyes is still distinct in specimens captured at depths down to 1200 m., but disappears completely in the animals from greater depths, though the eyes always exist. It may be taken as certain that his specimens from deep water belong to this species, while I am inclined to suppose that all those from 1007 to 1924 m. belong to a species closely allied to *C. neglecta* ; but not having seen any of these specimens, I cannot settle the question. I may add that it is probably almost without parallel that a species which has been taken in several places far from each other in depths ranging from about 8 to 25 fathoms, should not occur in depths from about 25 (or at most 50 fathoms) and down to more than 500 fathoms, but yet should have been found not less than eight times in depths from about 550 to 1000 fathoms. Besides, I can state from personal experience that species of the genus *Cirolana* are frequently so closely allied that a minute examination of the shape of the posterior thoracic epimera, the shape and armature of last abdominal segment, the length and breadth of the rami of the uropoda, the distribution of plumose setæ on seventh thoracic legs, &c., is necessary in order to avoid erroneous determination.

Remarks.—This species is distinguished from the two preceding forms by shape and colour of the eyes, the posterior thoracic epimera, the second joint of seventh thoracic legs, the shape and armature of last abdominal segment, and the comparatively greater breadth of the rami of the uropoda. In the paragraph on occurrence and distribution some further remarks on the species—or two species—are found.

4. CIROLANA SCHMIDTII, n. sp.   (Pl. **33**. figs. 2 *a–2 c*.)
             Adult female and immature specimens.

Eyes completely wanting; the lateral margins of the head show a kind of ridge from the base of the antennula to the front angle of thorax, and the lower side of the head close inside that ridge is conspicuously excavated.

Frontal plate about as in *C. borealis*. Clypeus considerably shorter than in *C. borealis* or *C. neglecta*, with the usual marginal furrows, but the area limited by these furrows is scarcely convex.

Antennulæ nearly as in *C. neglecta*; flagellum with about twelve very short joints.

Antennæ do not reach fully to the middle of thorax; flagellum in the two largest specimens with about twenty joints.

Epimera nearly as in *C. neglecta*, but those of seventh segment a little less produced; the oblique furrow well developed on all epimera, reaching their posterior margin.

Seventh thoracic legs more slender than in the preceding species; otherwise nearly as in *C. neglecta*. Second joint strongly flattened and considerably expanded, a little more than twice as long as broad; its outer margin and the ridge on the lower surface closely set with plumose hairs, which are long at the margin, much shorter on the ridge; the inner margin is naked nearly to the most distal, almost transverse short part, which is closely set with exceedingly long plumose setæ. Fourth joint as long as the fifth and slightly shorter than the sixth.

Last abdominal segment with a subbasal transverse impression more pronounced than in the preceding species; the lateral margins rather feebly convex, not angular, with six pairs of distal spines; the end is more or less acute.

Uropoda broader than in *C. borealis*, but less broad than in *C. neglecta*. The endopod, which reaches slightly beyond the tip of abdomen, is rather more than twice as long as broad, without any notch at the end of the outer margin. Exopod between four and three and a half times longer than broad, considerably shorter than the endopod.

Length of a female with marsupium 12 mm.; the immature specimen, parts of which are shown on the Plate, measures 9·5 mm. in length.

Occurrence.—In 1895 an adult female and two rather small specimens were taken by the 'Ingolf' Expedition in the Davis

Strait, Station 25 : lat. 63° 30′ N., long. 54° 25′ W., 582 fathoms, temperature at the bottom 3°·6 C. In May 1904, the specimen figured was captured west of the most southern of the Färoe Islands, in lat. 61° 15′ N., long. 9° 35′ W., 872–970 metres, by Dr. Joh. Schmidt (the cruise of the 'Thor,' the Danish ship in the service of the international marine investigations of the Northern European Seas).

Remarks.—The species is rather closely allied to *C. neglecta*, H. J. H., but distinguished at a glance by the complete absence of visual elements and the shape of the lateral part of the head ; besides it shows several minor differences pointed out in the description. From *C. cæca*, Dollf., it differs in possessing well-developed furrows on the thoracic epimera. The name is chosen in honour of Dr. Joh. Schmidt, who during the cruises of the 'Thor' in the seas of Iceland and the Färoe Islands collected a great number of interesting Crustacea (and other animals), several of which are new to science.

5. CIROLANA CÆCA, *Dollf.* (1903).

1903. *Cirolana cæca*, A. Dollfus, Bull. Soc. Zool. France, vol. xxviii. p. 6.
   Eyes quite wanting.

Frontal plate " very narrow, longitudinally canaliculated, about three times as long as broad."

Antennulæ short, with three-jointed peduncle, and flagellum consisting of twenty or twenty-one joints.

Epimera of second to sixth thoracic segments without any trace of oblique furrow, while the usual submarginal furrow is conspicuous. Seventh epimera considerably smaller than the sixth, with the oblique furrow rather feebly developed.

Seventh thoracic legs have the second joint shaped nearly as in *C. Schmidtii*, with the natatory setæ distributed as in this species.

Last abdominal segment subtriangular, proportionately a little longer than in *C. Schmidtii*, with the end narrowly rounded.

Uropoda nearly as in *C. Schmidtii* ; the endopod not quite so broad as in that species.

The species is rather closely allied to *C. Schmidtii*.

Length of an egg-bearing female, 9 mm.

Occurrence.—Dollfus enumerates five stations in the western half of the Mediterranean, with depths from 1210 to 2500 m.

'Porcupine' (1869) St. 36 : lat. 48° 50′ N., long. 11° 9′ W., 725 fathoms (the locality at the entrance of the English Channel), one specimen in Canon Norman's Collection.

Remarks.—Of this small and blind deep-sea species only a preliminary description, without figures, has been published. [In the original manuscript I gave only an abstract of this description; but having subsequently received a specimen from Canon Norman, some additional observations have been inserted. *C. cæca* is sharply distinguished from *C. Schmidtii* and *C. neglecta* by the absence of eyes and of furrows on the epimera; it is much more related to the preceding species than to *C. microphthalma*, Hoek, and allied exotic forms.]

6. CIROLANA MICROPHTHALMA, *Hoek* (1882).

1882. *Cirolana microphthalma*, Hoek, Nied. Archiv für Zool., Supplementband, i. p. 28, pl. ii. figs. 13–17.
1897. *Cirolana microphthalma*, G. O. Sars, Crust. of Norway, vol. ii. p. 71, pl. 36. fig. 1.
1903. *Cirolana microphthalma*, Dollfus, Bull. Soc. Zool. France, vol. xxviii. p. 9.

" Eyes very small, black."

Frontal plate " narrow, elongate and canaliculated."

Antennulæ about as long as the peduncle of the antennæ, rather similar to those of *C. borealis.*

Antennæ with the flagellum very much shorter than in *C. borealis, C. gallica,* or *C. neglecta,* consisting of at most thirteen joints.

(Epimera of seventh thoracic segment probably considerably larger in proportion to those of sixth segment than in *C. gallica* or *C. neglecta.*)

Seventh thoracic legs have the second joint less flattened and about three and a half times longer than broad, with a few short setæ near the base of the outer margin, no setæ on the inner margin except on its distal end, and a rather small number of setæ along the ridge on the lower surface. Fourth joint elongate, a little longer than the fifth and much longer than the sixth.

Last abdominal segment posteriorly either rounded or " obtusely truncated," with about three pairs of short spines.

Uropoda moderately broad. Endopod, when directed parallel with the axis of the animal, reaches a little beyond the end of abdomen ; it is nearly two and a half times as long as broad, its outer margin considerably bent—convex or nearly angular— beyond the middle, but the distal part more or less distinctly

concave. Exopod somewhat shorter than the endopod, more than four times longer than broad, " without any marginal spinules."

Length of the largest specimen known 33 mm. (Dollfus); Hoek's typical specimen measured 23 mm.

Occurrence.—Hoek's single specimen was captured in lat. 73° 13′ 5″ N., long. 30° 42′ E., 166 fathoms. Sars has seen one specimen from lat. 70° 36′ N., long. 32° 35′ E., 148 fathoms, and a second from Storeggen (western coast of Norway), 50 fathoms. Dollfus records a single specimen from lat. 65° 41′ N., on the coast of Norway, 440 m.

Remarks.—This species is easily distinguished from all other forms hitherto found in Europe by the shape of the seventh thoracic legs; the small black eyes, the very short antennæ, the end of abdomen, &c., exhibit other good characters.

Unfortunately I have seen no specimen of this interesting form; my diagnosis has been compiled from the descriptions of the three authors in question, to which I add characters to be seen especially on the figures given by Sars. It was necessary to do so, because the descriptions named are rather incomplete; furthermore, no figure of the thoracic epimera, seen from the side, has been published, and these epimera have not been described.

The species is rather closely allied to *C. concharum*, Stimps., *C. polita*, Stimps., and *C. impressa*, Harger, all from the eastern coast of the United States. It is to be hoped that a more detailed description with some additional correct figures may soon be published, so that it may be easily distinguished from the American species mentioned; moreover, I do not think it impossible that one of these American forms may eventually be discovered in European seas.

Group B.

Frontal plate at most half as long again as broad. Three posterior pairs of thoracic legs without natatory setæ, or at most with a few plumose setæ at the outer margin of second joint.

7. CIROLANA CRANCHII, *Leach* (1818). (Pl. **33**. fig. 3 *a*.)

1890. *Cirolana Cranchii*, H. J. Hansen, Cirolanidæ, &c., p. 341, pl. iii. figs. 3–3 *i*.

1892. *Conilera grampoides*, P. Gourret, Ann. Mus. d'Hist. natur. Marseille, vol. iv. fasc. ii. Zool. Mém. 1, p. 11, pl. i. fig. 7; pl. iii. figs. 4–11.

Eyes moderately large, black, seen from the side longer than deep, with the upper margin slightly convex.

Frontal plate small, pentagonal, at most one half as long again as broad ; its front end acute, not visible from above. Clypeus without any anterior process ; its surface slightly convex, with a furrow along each lateral margin.

Antennulæ about as long as the peduncle of the antennæ ; flagellum moderately slender, with about fifteen joints.

Antennæ long, reaching much beyond the middle of thorax ; flagellum with numerous, sometimes even more than forty, joints.

Epimera of the thoracic segments increase gradually in size backwards ; each has a deep oblique furrow besides the sub-marginal one.

Seventh thoracic legs without natatory setæ but with numerous simple, acute spines, and some very short hairs ; second joint very robust, twice as long as broad ; fourth joint a little shorter than fifth, which is somewhat shorter than sixth.

Last abdominal segment subtriangular, posteriorly rather narrowly rounded, with four to six pairs of marginal spines.

Uropoda rather broad. Endopod, when directed parallel with the axis of the animal, reaches considerably beyond the end of abdomen ; it is from a little less (in small specimens) to a little more (in large specimens) than twice as long as broad. Exopod about three times as long as broad, somewhat shorter than the endopod.

Differences according to Age.—Large, and especially very large, specimens differ from smaller ones in shape and clothing of last abdominal segment and uropoda. In smaller specimens the upper surface of this segment is distinctly convex, glabrous, or at most with a number of nearly inconspicuous elevated points, while the distal half of the lateral margins is feebly convex or at most straight. In large, and especially in very large, specimens a large portion of the upper surface is flat or even slightly depressed, adorned with numerous conspicuous elevated points ; the distal half of the lateral margins is a little concave, wherefore the corresponding part of the segment is more narrow than in young specimens. The uropoda show the following differences. In smaller specimens the outer margin of the endopod is rather regularly but feebly convex and the end acute ; on both rami the clothing of setæ is of normal density on both margins, so that all marginal spines are easily seen. In large, and especially very

large, specimens the outer margin of the endopod is a little bent
before or beyond the middle, the margin beyond this very
obtuse angle is straight, and the end is more or less rounded;
this straight part of the outer margin of the endopod and the
distal half or two-fifths of both margins of the exopod are so
densely clothed with fine hairs that the marginal spines, if
present, cannot be perceived; the clothed portion of the exopod
has also altered its shape a little.

Pl. iii. fig. 3 *i*, in my paper quoted, conveys a good idea of
the shape and clothing of spines and setæ of the last abdominal
segment and uropoda in smaller specimens. Fig. 2 *g*, on the
same plate, represents the same parts of a rather large animal, in
which the shape of abdomen is seen, while the uropoda have not
fully arrived at their final shape. For this reason I give here a
new figure (Pl. **33**. fig. 3 *a*) of the right uropod of a large
specimen.

Length of the largest specimen seen, a female without mar-
supium, taken at Belle-Isle, is 18 mm.

Occurrence.—According to the literature this species has been
secured at Cumbrae (Firth of Clyde, western coast of Scotland),
Plymouth and Falmouth (Sp. Bate & Westwood), the Channel
Islands, Roscoff, Concarneau and Le Croisic (various French
authors); my earlier specimens were from Villefranche, and
Leach had his *Nelocira Swainsoni* from Sicily; Miers mentions
the species from Goree Island, Senegambia, but the specimens
from this locality ought to be re-examined. Mr. Dollfus's col-
lection contains many specimens from the following localities:—
Le Croisic, two very small specimens in a dead *Cancer pagurus*
and two specimens in a *Maja*; Belle-Isle, one specimen from 70 m.,
and two specimens in cavities in a piece of wood hauled up in
the dredge; Isle d'Yeu, one specimen from 100 m.; Guéthary,
near Biarritz: all four localities are on the western coast of
France. Also from the following places in the Mediterranean:
Villefranche; Cannes, 1–5 m.; not far from Toulon, ten small
specimens in the mouth of *Grampus griseus*; Porto Vecchio
(Corsica); finally Gabès (Tunis), in sponges.

Remarks.—*C. Cranchii* is easily distinguished from all other
European species by the shape of the frontal plate; eyes, epimera,
thoracic legs, &c. show other excellent characters. As to the
synonymy, especially Leach, Risso, and G. O. Sars, I refer to
my earlier paper. In 1892, P. Gourret established a new form,
Conilera grampoides, on ten specimens taken in the mouth of a

Grampus griseus. I applied to the zoological authorities in Marseilles in order to obtain Gourret's types for study, but in spite of careful searching they could not be found and are probably lost. His description and most of his figures are not sufficient for recognition of the species; but according to his fig. 9, which represents the abdomen and one of the uropoda, the animals do not belong to *Conilera,* but are young stretched specimens of *Cirolana Cranchii.*

8. CIROLANA HANSENI, *Bonn.* (1896). (Pl. **33**. figs. **4** *a*–4 *d* ; Pl. **34**. figs. **1** *a*–1 *k.*)

1882. *Eurydice polydendrica,* Norman & Stebbing, Proc. Roy. Soc. Edinburgh, vol. xi. pp. 665 & 684. [*Nomen nudum,* without description or figures.]

1896. *Cirolana Hanseni,* J. Bonnier, "Campagne du Caudan," Ann. l'Univers. Lyon, t. xxvi. p. 574, pl. xxxii. figs. 1 *a*–1 *o.*

Head more or less angular in front of the small black eyes.

Frontal plate very large, slightly longer than broad, increasing much in breadth from the middle to the anterior end, which is cut off with the front margin slightly concave. Between this lower front margin and the anterior end of the process (between the antennulæ) from the upper surface of the head the frontal plate shows a triangular surface looking forwards, and this surface is partly visible when the head is seen from above. On the lower side of the plate the lateral margins and the front margin are thickened, forming elevated ridges between which an impressed area is seen.

Clypeus anteriorly produced into a triangular, basally very broad and distally rounded, nearly lamellar process, which proceeds downwards and forwards below the basal part of the frontal plate.

Antennulæ slender, somewhat longer than the peduncle of the antennæ ; peduncle three-jointed ; the flagellum consists of four proportionately long and some minute joints.

Antennæ do not reach to the middle of thorax ; flagellum about as long as the peduncle, with eleven joints.

Epimera of the thoracic segments increase in size and in the degree of being produced backwards from the second to the sixth, while the seventh is considerably smaller than the sixth. All epimera are strongly carinated, and the posterior pairs rather excavated behind their oblique carina.

Seventh thoracic legs unusually slender. Second joint somewhat more than three times as long as broad, along the outer margin with several very short hairs and a few long setæ, each of which has proportionately few long lateral branches; the other margin and the lower surface without setæ. Fourth joint much longer than broad, much shorter than fifth and scarcely more than half as long as the sixth; these joints without setæ, but with some slender spines.

Abdomen increases much in breadth from first to third segment. Lateral angles of fifth segment covered by the fourth.

Last abdominal segment almost as long as broad, posteriorly broadly rounded and irregularly serrate, probably without marginal spines, but with setæ in the incisions between the saw-teeth.

Uropoda broad. Endopod, when parallel with the axis of the animal, reaches scarcely beyond the end of abdomen; it is nearly twice as long as broad, with some coarse serrations along each margin, its end with a small incision between two saw-teeth. Exopod much shorter than the endopod, not fully three times longer than broad; its end shaped and its margins serrate nearly as those of the endopod. Both rami without movable spines, but with setæ as on the distal margin of abdomen.

Length of the largest specimen (Norman's type) 4·2 mm.

Occurrence.—Norman mentions the species from lat. 59° 37′ N., long. 7° 19′ W., 530 fathoms; in material received from him I found one specimen from lat. 59° 34′ N., long. 7° 18′ W., 543 fathoms, and three specimens from lat. 59° 70′ N., long. 7° 21′ W., 516 fathoms (H.M.S. 'Triton,' 1882). Bonnier's single specimen was dredged in the Gulf of Gascogne (Bay of Biscay), lat. 44° 36′ N., long. 4° 25′ W., 650 m.

Remarks.—This species differs—especially in the frontal plate, clypeus, and seventh thoracic legs—strongly from all other European forms, but is rather closely allied to *C. japonica*, H. J. H. Probably all specimens seen by me are immature; unfortunately the largest specimen was exsiccated, the glass tube being crushed on the way from Berkhamsted to Copenhagen.

A long time after I had finished the drawings of this species I became aware that the minute specimen—measuring 1·7 mm. in length—described and figured by Bonnier was the same form. As *Eurydice polydendrica*, Norm. & Stebb., had never been described nor figured, it was necessary to drop this name and

adopt that given by the French author.—On Pl. **34** I have figured the mouth-limbs from the left half of a specimen; they show great similarity to those of *C. japonica*, H. J. Hansen (Cirolanidæ, pl. 4).

II. CONILERA, *Leach*.

The characters of the genus are given in the conspectus of the genera.

The genus comprises as yet only one marine species, *C. cylindracea*, Mont. (and an American freshwater form). I have stated above that *Conilera grampoides*, Gourret, does not belong to this genus, but that the form is only *Cirolana Cranchii*, Leach.

1. CONILERA CYLINDRACEA, *Mont.* (1803).

1868. *Conilera cylindracea*, Sp. Bate & Westwood, Brit. Sess.-eyed Crust. vol. i. p. 304 [with figures].

1890. *Conilera cylindracea*, H. J. Hansen, Cirolanidæ, &c. p. 358, pl. iv. figs. 5–5 *c*; pl. v. figs. 1–1 *d* [with synonymy, biology, &c.].

A detailed description, with several figures, of this characteristic very slender form will be found in my paper quoted. It is deemed sufficient to give here some remarks on dimension, variation, and distribution.

Length.—An egg-bearing female and a male from Naples measured respectively 19·3 mm. and 20·5 mm. in length. Some specimens in a very rich material from Roscoff are considerably larger—the largest one, a female without marsupium, measuring 28·7 mm. in length and 5·5 mm. in breadth.

Variation.—In my previous paper I have drawn attention to some utterances by Yves Delage in 1881 and R. Koehler in 1885. Delage writes that his *Conilera* from Roscoff is perhaps not identical with the species described by Bate & Westwood, differing " par les antennes, par les appendices natatoires du sixième anneau abdominal et par des ponctuations rouges dont les auteurs anglais spécifient l'absence." Koehler quotes Delage, and adds: " Je possède des *Conilera* de Naples dont les caractères s'accordent absolument avec la description des auteurs anglais et dont les échantillons de Jersey diffèrent par les caractères suivants : longueur des appendices du dernier anneau abdominal, longueur des poils portés par le quatrième article des antennes inférieures, et enfin présence sur la carapace de

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nombreuses petites taches rouges." I have examined some rich material from Roscoff, but I am unable to discover any difference between specimens from this locality and those from Naples in the antennæ or the uropoda. Many of the specimens from Roscoff are adorned with a very large number of fine greyish dots; in other specimens such dots are rather few in number, and in some specimens they have completely disappeared, so that they cannot be distinguished from those from Naples; I suppose that the greyish dots are red in living animals. It may be added that specimens from Le Croisic and Concarneau presented similar dots. The absence of such dots is not always a specific difference, some specimens of *Cirolana borealis* being adorned with hundreds of dots, while very few or no dots are found on other specimens preserved in spirit.

Occurrence.—In my earlier paper it was stated that this interesting form had been captured on the southern and western coasts of Great Britain northwards at least to the Firth of Clyde, at the Channel Islands, Roscoff, south-western coast of Brittany, finally at Naples. A. O. Walker records it from Bantry Bay, west coast of Ireland. Mr. Dollfus's collection contains many specimens from some localities on the south-western coast of Brittany; for instance, five rather small animals taken on "la voûte palatine et orbite d'un Dauphin pris à Concarneau," and seven specimens in a *Maja* at Le Croisic.—Miss Richardson (Proc. U.S. Mus. xxiii. p. 515) states that this species has been taken in two places in the southern part of the United States, viz., "off South Carolina; between the Delta of the Mississippi and Cedar Keys, Florida." I am, however, inclined to believe that the specimens in question belong to an undescribed species, and the author does not say if she has compared them with European specimens of *C. cylindracea*.

III. EURYDICE, *Leach*.

The essential characters of the genus are given in the conspectus of the genera.

Six species (not counting *E. pontica*, Czern.) live in the seas of Europe. All are very similar in general aspect; besides, the males of some of the species differ in certain conspicuous features more from their females than examples of the latter sex belonging to different species. Eyes, antennulæ, flagellum of antennæ, relative length of abdomen, and sometimes the uropoda

show more or less conspicuous sexual differences; among these especially the antennulæ afford good specific characters. Clypeus, epimera of the thoracic segments, seventh thoracic legs, and last abdominal segment show excellent specific characters, but scarcely any sexual difference; finally, the shape of the "appendix masculina" (second joint of the endopod) of second pleopoda differs in all species. Specimens rather far from sexual maturity differ in some features more or less from adults; especially small males differ generally from adult specimens of the same sex in the structure of the antennulæ, length of flagellum of antennæ, and relative length of abdomen, while other features, as clypeus, epimera, and shape of last abdominal segment, are nearly or quite similar in immature and adult specimens. When good material is at hand, it is possible to determine even half-grown specimens with absolute certainty; but great caution is always necessary, as the animals are closely allied to each other and far from easy to separate. It is not my intention to give very detailed descriptions; in my papers from 1890 to 1895 at least one of the sexes, and sometimes both, of five of the six species have been described and illustrated by numerous figures. Having obtained one new species, the hitherto unknown male of *E. inermis*, the female of *E. truncata*, &c., I am able to communicate some further details; besides, I shall attempt to furnish two keys and shorter descriptions as practical as possible for discrimination of the forms.

Our knowledge of the geographical distribution of the species described here is still imperfect; especially the Mediterranean has not been explored, and, for instance, the statements of Gourret and Lo Bianco on the occurrence of *E. pulchra* off the southern coast of France and off Capri are not trustworthy. It is even not improbable that some new species may be discovered in the western part of the Mediterannean or on the Atlantic coast of Spain and Portugal.

Conspectus of the Species.

I.

A. Posterior margin of last abdominal segment rather deeply emarginate, with two conspicuous movable spines close to each other at each end. Epimera of second to fourth thoracic segments produced into rather long processes .... 1. *E. spinigera*, H. J. H.

B. Posterior margin of last abdominal segment never emar-
    ginate, but conspicuously convex or nearly straight ;
    movable spines, if present, rather small and distant
    from each other. Epimera of second to fourth thoracic
    segments either not produced or with exceedingly small
    processes.
  a. Posterior margin of last abdominal segment at least
    half as long as the breadth of the segment (at each
    end with a prominent tooth but without marginal
    spines). Processes of epimera of sixth segment
    moderately short, about as large as those of seventh
    epimera .... 2. *E. Grimaldii,* Dollf.
  b. Posterior margin of last abdominal segment con-
    siderably less than half as long as the breadth of
    the segment. Processes of epimera of sixth segment
    either wanting or much longer than those of seventh
    epimera.
    α. Epimera of sixth segment with moderate or rather
      large processes.
      † Process from clypeus small, seen vertically from
        below covering a minute part of the space be-
        tween the mandibular palps. Epimera of fifth
        segment with a conspicuous process. Posterior
        margin of abdomen without movable spines, at
        each end with a conspicuous tooth, and just
        outside this (in large animals) a minute pro-
        truding angle .... 3. *E. truncata,* Norm.
      †† Process from clypeus large, seen vertically from
        below covering the whole space between the
        mandibular palps. Epimera of fifth segment
        without any process. Posterior margin of
        abdomen with four movable spines, but without
        any distinct tooth at the end.... 4. *E. pulchra,* Leach.
    β. Epimera of sixth segment with exceedingly small
      processes or without any process at all.
      † Process from clypeus of considerable size, seen
        vertically from below covering the major portion
        of the space between the mandibular palps.
        Posterior margin of last abdominal segment
        slightly longer than one-third of the breadth of
        the segment, with four marginal spines.

                         5. *E. affinis,* n. sp.
      †† Process from clypeus very small, seen vertically
        from below covering a minute portion of the
        space between the mandibular palps. Posterior
        margin of abdomen very short, even less than
        one-fourth as long as the breadth of the seg-
        ment, without marginal spines. 6. *E. inermis,* H. J. H.

II.

A. Process of clypeus, seen vertically from below, covers at least the major portion of the space between the mandibular palps.

   a. Posterior margin of last abdominal segment rather deeply emarginate, with two conspicuous movable spines at each end. Epimera of second to fourth thoracic segments produced into rather long processes .... 1. *E. spinigera,* H. J. H.

   b. Posterior margin of last abdominal segment not emarginate; movable spines, if present, rather small and distant from each other. Epimera of second to fourth thoracic segments without, or at most with quite minute, processes.

      α. Posterior margin of last abdominal segment at least half as long as the breadth of the segment, without movable spines .... 2. *E. Grimaldii,* Dollf.

      β. Posterior margin of last abdominal segment distinctly less than half as long as the breadth of the segment, with four movable spines.

         † Epimera of sixth thoracic segment with moderately large processes .... 4. *E. pulchra,* Leach.

         †† Epimera of sixth thoracic segment not produced into processes .... 5. *E. affinis,* n. sp.

B. Process of clypeus, seen vertically from below, covers only a small or very small portion of the space between the mandibular palps.

   a. Epimera of fifth and seventh thoracic segments produced into rather small processes, those of sixth segment with processes of considerable size. Posterior margin of last abdominal segment one-third as long as the breadth of the segment ...... 3. *E. truncata,* Norm.

   b. Epimera of three posterior thoracic segments at most with exceedingly small processes. Posterior margin of last abdominal segment even less than one-fourth as long as the breadth of the segment.

                           6. *E. inermis,* H. J. H.

1. EURYDICE SPINIGERA, *H. J. Hansen* (1890).

Male.

1890. *Eurydice spinigera,* H. J. Hansen, Cirolanidæ, &c. p. 367, pl. v. figs. 4–4 *c;* pl. vi. figs. 1–1 *c.*

Process from clypeus large, seen vertically from below covering the whole area between the mandibular palps.

Antennulæ reach scarcely to the front lateral angle of thorax. Peduncle rather thick, its third joint slightly shorter than the second. Flagellum rather robust; first joint about two and a half times as long as the three distal joints together, furnished with a good number of moderately long sensory hairs; terminal setæ short.

Peduncle of antennæ with the penultimate joint scarcely half as long as the terminal one.

Epimera of second thoracic segment produced into rather large, oblong processes; processes of the epimera of second to sixth segment increase gradually in size backwards, so that those of sixth segment are very long, considerably longer than in any other species; posterior margin of epimera of second to fifth segments conspicuously concave above the base of the process. Even the lateral posterior angle of first segment is produced into a rather good-sized process, and the posterior margin above its base is strongly concave. The processes from last pair of epimera are rather small.

Seventh thoracic legs less slender than in *E. Grimaldii*; fourth joint slightly longer than broad and considerably shorter than fifth; fourth and fifth joints on the lower surface with several spines more or less distant from the inner margin, and with numerous setæ more or less distant from the outer margin.

Last abdominal segment has on the upper surface a pair of deep, angular, sublateral impressions and a deep, transverse, anteriorly semicircular central impression at a short distance from the base. Hind margin about two-fifths as long as the breadth of the segment, rather deeply emarginate; lateral angles broadly rounded, each with two movable spines near each other, the inner of which is long.

Uropoda rather large: endopod, when parallel with the axis of the animal, reaches slightly beyond the abdomen.

Length 9 mm.

Occurrence.—The species was established on a large number of specimens, without locality, forwarded many years ago by Mr. A. H. Riise, apothecary in St. Thomas Island. Mr. Riise had presented the Copenhagen Museum with a rich collection of Crustacea (and numerous other marine animals), almost all collected by himself at the Danish Islands in the West Indies; for that reason I wrote in 1890 that this species was probably from the West Indies, but this supposition must be erroneous,

as since 1890 the species has been secured twice in England.
I therefore now think that my specimens were captured some-
where in the eastern part of the Atlantic, on the way from
Denmark to St. Thomas.   Stebbing (1895) has discovered
E. spinigera at Ilfracombe, at the entrance of the Bristol
Channel, and his remarks as to its characters prove the cor-
rectness of the determination.   In 1903 Canon A. M. Norman
told me in a letter that he the same summer had captured this
species at Plymouth.   Finally, A. O. Walker & J. Hornell
(Journ. Marine Zool. ii. p. 51) record it from the Channel Islands,
but as they add the erroneous remark, " probably identical with
E. truncata, Norman," the determination is, in my opinion, less
trustworthy.

Remarks.—This rather large species is easily separated from
all other forms by the highly-developed armature of the thoracic
segments and by the shape and armature of the posterior margin
of abdomen.

2. EURYDICE GRIMALDII, *Dollf.* (1888).

Male and female.

1888. *Eurydice Grimaldii*, A. Dollfus, Bull. Soc. Zool. France, vol. xiii.
    p. 6.
1890. *Eurydice elegantula*, H. J. Hansen, Cirolanidæ, &c. p. 364, pl. v.
    figs. 2–2 *t.*

Process from clypeus large, seen vertically from below covering
at least the major part of the area between the mandibular
palps.

Antennulæ.—Male : Peduncle strongly thickened, much thicker
than in the female, but third joint shorter than in that sex,
about as long as second joint ; flagellum reaches the anterior
lateral angle of thorax, its first joint is thickened, especially
towards the base, compressed and furnished with an immense
number of very long sensory hairs, while the four other joints
are very short, and their combined length is more than three times
shorter than first joint ; one of the terminal setæ is somewhat
longer than these four distal joints together.   Female : of normal
size ; third joint of the peduncle a little longer than the second ;
flagellum reaches to the anterior lateral angle of thorax, its first
joint is somewhat shorter than in the male, less compressed,
scarcely thickened, with a moderate number of shorter sensory
hairs, more than three times longer than the remaining joints
together ; terminal setæ short.

Peduncle of antennæ with the penultimate joint conspicuously more than half as long as the terminal one.

Epimera of second to fourth thoracic segment produced in quite rudimentary or very small processes; epimera of fifth segment with the process a little longer, those of the two posterior segments produced into moderately short processes nearly equal in size.

Seventh thoracic legs slender; fourth joint considerably longer than broad and a little shorter than the fifth; fourth and fifth joints without spines or setæ on the lower surface, the margins themselves excepted.

Last abdominal segment has on the upper surface a deep transversely oval impression at most one-third as broad as the segment, and besides sometimes at each end of this central excavation, and touching it, a feeble sublateral impression. Hind margin nearly straight or slightly convex, at least half as long as the breadth of the segment, without movable spines, but at each end limited by a very conspicuous triangular tooth.

Uropoda proportionately considerably larger in the male than in the female, but their natatory setæ are longer in the female than in the male. The endopod, when parallel with the axis of the animal, reaches a little beyond the abdomen.

Length of the male 5–7 mm., of the female 7–8·5 mm.

Occurrence.—I have seen specimens from lat. 56° N., long. 18° W., and off South-western Iceland, lat. 63° 21′ N., long. 25° 21′ W.; furthermore from the sea from these two places to the most northern part of Scotland, and especially to and around the Färoe Islands: in this area it has been captured twelve times, always distant from the coast, and probably always pelagic, though in a few instances it was taken in the dredge or the trawl. According to A. O. Walker (Trans. Liverp. Biol. Soc. xii. p. 165) it has been secured on the west coast of Ireland, at Outer Harbour, Killiebegs, Co. Donegal, 14–16 fathoms. In material received from Canon Norman I found a single specimen from the 'Porcupine' Expedition: St. 29, off Cadiz, Spain, 227 fathoms. Dollfus records it from the Azores: "Au large de Porta Delgada, île San Miquel, . . . surface."

Remarks.—The species is easily distinguished from all other European forms by having the transverse hind margin of the abdomen long, without movable spines, but limited at each end by a conspicuous triangular tooth; antennulæ, epimera, &c. afford

other good characters. When, in 1890, I established this species as *E. elegantula*, I wrote that until further evidence was procured I thought it better not to regard my species as identical with *E. Grimaldii*, Dollf., from the Azores; the latter form being very imperfectly characterized, and the flagellum of its antennulæ described as one-jointed. The examination of typical specimens of *E. Grimaldii*, Dollf., kindly forwarded me by Mr. Dollfus, showed that this species is identical with mine; the name given by me must therefore be cancelled.

3. EURYDICE TRUNCATA, *Norm.* (1868). (Pl. **34**. figs. 2 *a*–2 *b*.)

Male and female.

1868. *Cirolana truncata*, A. M. Norman, Ann. Mag. Nat. Hist. ser. 4, vol. ii. p. 421, pl. xxiii. figs. 12–15 (female).

1890. *Eurydice truncata*, H. J. Hansen, Cirolanidæ, &c. p. 375. [Without description, but giving occurrences and the literature concerned.]

1895. *Eurydice truncata*, H. J. Hansen, Isopoden, Cumaceen, und Stomapoden der Plankton-Expedition, p. 13, pl. i. figs. 5–5 *h* (male).

Process of clypeus small, seen vertically from below covering a minute portion of the area between the mandibular palps.

Antennulæ.—Male : The antennulæ reach behind the anterior lateral angle of second thoracic segment. Peduncle considerably thickened; third joint shorter than the second. Flagellum rather robust at the base, otherwise slender, very elongate; first joint somewhat shorter than the combined length of the four others, with a large number of moderately long sensory hairs; second joint much shorter than the third, which is a little longer than the fourth; the minute terminal joint with a few setæ, one of which is robust and exceedingly long, almost longer than the whole flagellum.—Female (Pl. **34**. fig. 2 *b*) : The antennulæ reach to the anterior lateral angle of thorax. Peduncle moderately slender; third joint considerably shorter than the second. Flagellum slender; first joint only slightly longer than the four others together, with a moderate number of sensory hairs; second joint conspicuously shorter than third or fourth; terminal minute joint with some setæ, the longest of which is slightly longer than the three distal joints combined.

Peduncle of antennæ with the penultimate joint conspicuously more than half as long as the terminal one.

Epimera of second, third, and fourth thoracic segments scarcely or not at all produced behind; epimera of fifth segment produced

into a rather small, yet very conspicuous process; epimera of sixth segment produced into rather long processes, much longer than those of seventh epimera.

Seventh thoracic legs slender; fourth joint much longer than broad, a little shorter than the fifth; fourth joint with one or two spines; fifth joint with one spine on the lower surface rather removed from the inner margin.

Last abdominal segment has on its upper surface a transverse broad impression, often connected at each end with a faint transverse sublateral impression. Posterior margin about one-third as long as the breadth of the segment, distinctly convex, finely serrate, without movable spines, at each end with a conspicuous or even rather large triangular tooth, and at the outer base of this tooth another very small tooth or minute projecting angle.

Length of an adult male from Naples 4·2 mm.: of a female without marsupium from Shetland 7·2 mm.

Occurrence.—Norman's type specimen was dredged by him in St. Magnus Bay, Shetland, 40–60 fathoms (a specimen from this locality has been examined by me, from which my two figures are taken); many years after it was obtained in lat. 59° 28′ N., long. 6° 33′ W., 53 fathoms (Norman). In material from Mr. Dollfus I found two specimens captured near Concarneau, south-western coast of Brittany, 50–60 m.; one specimen near Belle-Isle; numerous not half-grown specimens from La Banche, France, 17 m., and three specimens from the coast of Morocco, 130 m. The male described by me in 1895 was secured at Naples. Lo Bianco (Mitt. Zool. Stat. Neap. xxiii. p. 196) records two specimens obtained by Mr. F. A. Krupp in the Mediterranean, in the open sea, at two stations some miles from Capri. The species is probably always pelagic.

Remarks.—Adult specimens of this species are easily distinguished from all other forms by the flagellum of the antennulæ and by the hind margin of abdomen, where the existence of a minute tooth or sharp angle outside a rather large tooth is very characteristic. The epimera are very similar to those of *E. pulchra*, but in the latter species the fifth epimera are without real processes. In half-grown or still smaller specimens the structure described of the angles at the posterior margin of abdomen is often obscure, but they can be recognized with certainty by the small process from clypeus, by antennulæ and epimera. At least

such small specimens have probably sometimes been referred to *E. pulchra* by zoologists.

4. EURYDICE PULCHRA, *Leach* (1815). (Pl. **34**. figs. 3 *a*–3 *c* ; Pl. **35**. fig. 1 *a*.)

Male and female.

1890. *Eurydice pulchra*, H. J. Hansen, Cirolanidæ, &c. p. 370, pl. vi. figs. 3–3 *i* [with synonymy, &c.]
1897. *Eurydice pulchra*, G. O. Sars, Account Crust. Norw. vol. ii. p. 73, pl. xxx. fig. 2.

Process of clypeus large, seen vertically from below covering the whole area between the mandibular palps.

Antennulæ rather similar in both sexes, reaching to the anterior lateral angle of thorax. Peduncle moderately thick, its third joint a little longer than the second. Flagellum in the male with the first joint thick, considerably longer than the third joint of the peduncle, scarcely twice as long as the distal joints of flagellum combined and furnished with a large number of rather short sensory hairs ; in the female the first joint of flagellum is shorter and more slender, yet somewhat longer than third joint of the peduncle ; in both sexes the second joint is about as long as thick, longer than the third ; terminal setæ very short.

Peduncle of antennæ with the penultimate joint at most half as long as the terminal one.

Epimera of second to fifth thoracic segments not produced into processes ; those of sixth segment with a moderately long process ; epimera of seventh segment with rather small processes.

Seventh thoracic legs broader than in any other species. Fourth joint only a little longer than broad and somewhat shorter than the fifth ; both these joints on the lower surface with some spines rather removed from the inner margin and some spines rather near the outer margin.

Last abdominal segment has on its upper surface a deep transverse, but yet not broad impression, the anterior margin of which is considerably curved, and besides a pair of sublateral, conspicuous, irregular impressions not connected with the central one. Posterior margin at most a little more than one-third as long as the breadth of the segment, rather convex, finely serrate, without any distinct tooth at the ends, but armed with two pairs of movable spines ; the spines on each half somewhat distant from each other.

Length of an adult male 4·2 mm.; of large females without marsupium 7 mm.

Occurrence.—From various localities in Denmark I have seen a large number of specimens; it seems to be rather common in Kattegat and around our Islands between Jutland and Sweden; it is mentioned in the literature from the Bay of Kiel and from Travemünde. The animal figured by Sars certainly belongs to this species, and according to him it is met with in Christianiafjord and on the southern and western coasts of Norway northward at least to Trondhjem. Norman mentions it from St. Magnus Bay, Shetland, and Th. Scott from Lerwick Bay, Shetland, which in all probability are correct statements. Material from Mr. Dollfus contained specimens from the Firth of Clyde, western coast of Scotland; from five localities on the northern coast of France, viz. Crotoy between Boulogne and Dieppe, Trouville and Villers not far from Le Havre, Carteret on the western coast of Normandy, and St. Lunaire near St. Malo (at the last-named place a specimen was taken in a puddle on the beach); finally, from two localities at the western coast of France, viz. Belle-Isle, off the southern coast of Brittany, and Pontaillac, near Royan, Charente-Inférieure. In 1890 I put together several other statements found in the literature (and biological notes) on its occurrence in localities situated within the area circumscribed by the above-named places, for instance, at Portel (rather near Boulogne), on the coasts of Belgium, Holland, and Great Britain; but it is not improbable that the specimens observed at some of the places mentioned by earlier authors belonged to other species, especially *E. affinis*, n. sp., or *E. inermis*; on the other hand, it occurs, in all probability, on all the coasts in question. Finally, P. Gourret (Ann. Mus. Hist. Nat. Mars., Zool. iv. fasc. II. p. 13) speaks of its occurrence at Marseilles; according to 'Zool. Record' for 1896, Sowinsky has stated that it is found in the Black Sea; and Lo Bianco mentions eight specimens from seven localities, partly off Capri and partly from the sea between Monaco and the northern end of Corsica. I am, however, inclined to think that all these statements are erroneous [*].

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[*] Gourret's papers on Crustacea are, according to statements by other authors and my own judgment, far from trustworthy. It is easily seen from Lo Bianco's paper that Gourret was not acquainted with several carcinological papers of importance, and some of his determinations are either not correct or really misleading. He undertook the naming of species of nearly all groups of marine animals, but that task cannot be done well by any living zoologist.

Remarks.—E. pulchra is easily distinguished from all other European species—*E. affinis* to a certain degree excepted—by the shape and armature of the posterior margin of the abdomen; from *E. affinis* it is easily separated by having moderately large processes on the epimera of the sixth segment.   More than 120 years ago Slabber described and figured a *Eurydice*, "Agaat-Pissebet (Oniscus Achatus)," which may be this species, and therefore some few authors call it *E. achata*, Slabber, while most writers adopt the denomination given by Leach in 1815, *E. pulchra.*   It is rather probable that both Slabber and Leach examined the species described as *E. pulchra* in the present paper; but unfortunately I am not able to prove it in either case, as the distribution of *E. affinis*, n. sp., is too imperfectly known, and the old descriptions are insufficient for deciding the question; Slabber's original paper—the Dutch edition—is, besides, unknown to me.   For these reasons and in order to preserve, if possible, the name used in almost the whole literature, I adopt the denomination *E. pulchra*, Leach.

5. EURYDICE AFFINIS, n. sp.   (Pl. **35**. figs. 2 *a*–2 *k*.)
Male and (?) adult female.

Process of clypeus of considerable size, seen vertically from below covering the major portion of the area between the mandibular palps.

Antennulæ reach scarcely to the anterior lateral angle of thorax.—Male: Peduncle with the second joint somewhat thickened, third considerably thickened, but scarcely longer than the second.   Flagellum clumsy; first joint thick, somewhat elongate, as long as the combined length of the two distal joints of the peduncle and more than twice as long as that of the four distal joints of flagellum, furnished with numerous rather short sensory hairs; second joint thicker than long and longer than the third; terminal setæ short.—Female: Peduncle of normal moderate thickness; its third joint much longer than the second, and much longer but considerably more slender than in the male. Flagellum rather slender; first joint considerably shorter and much more slender than in the male, not longer than the third joint of the peduncle, and less than twice as long as the following joints combined, furnished with rather few sensory hairs; second joint longer than thick.

Peduncle of antennæ with the penultimate joint about half as long as the terminal one.

Epimera of the thoracic segments with the posterior angle sharp, at least on the posterior pairs, but none of them produced into processes.

Seventh thoracic legs rather broad; fourth joint somewhat longer than broad and rather shorter than the fifth; both these joints on the lower surface with in all a few strong spines at some distance from the inner margin, and no spines but a number of setæ near the outer margin.

Last abdominal segment has on its upper surface a moderately deep and rather broad transverse impression, the anterior margin of which is a little convex, while its ends are distinctly connected with good-sized sublateral impressions; from the inner end of each of these a longitudinal impression proceeds often forwards. Hind margin slightly longer than one-third of the breadth of the segment, at each end limited by a distinct but short tooth; the margin is somewhat convex, not distinctly serrate, armed with two pairs of movable spines, those on each half very distant from each other.

Uropoda rather large; endopod, when directed parallel with the axis of the animal, reaches considerably beyond the hind margin of the abdomen.

Length of an adult male 4 mm.; of a female without marsupium 4·2 mm.

Occurrence.—Of this species I have seen nearly 130 specimens from six localities on the northern and western coasts of France, viz., Carteret, on the western coast of Normandy; St. Lunaire, near St. Malo (88 specimens); Belle-Isle, off the south-western coast of Brittany; Pontaillac near Royan, Charente-Inférieure; Arcachon; finally, Hendaye, near the Spanish frontier. One specimen was labelled 35–60 m.; the numerous specimens from St. Lunaire and a specimen from Hendaye were taken swimming in puddles on the beach.

Remarks.—The species is easily distinguished from all other forms, *E. inermis* excepted, by the absence of processes on all thoracic epimera; from the last-named species it is easily separated by the length, shape, and armature of the posterior margin of abdomen. It is closely allied to *E. pulchra*, and has probably sometimes been referred to that species.—Fig. 2 *k* (Pl. 35) shows the " appendix masculina " of second pleopod; it is comparatively broader than in *E. pulchra*, but its terminal portion is shaped nearly as in that species.

6. EURYDICE INERMIS, *H. J. Hansen.* (Pl. 35. figs. 3 *a*–3 *c*.)
Male and female.

1890. *Eurydice inermis,* H. J. Hansen, Cirolanidæ, &c. p. 366, pl. v. figs. 3–3 *f* (female).

Process of clypeus very small, seen vertically from below covering a minute portion of the area between the mandibular palps.

Antennulæ.—Male : The antennulæ reach to the anterior lateral angle of thorax. Peduncle much thickened, especially its two proximal joints. Flagellum moderately robust at the base, otherwise slender; first joint somewhat compressed, a little longer than the combined length of the two distal joints of the peduncle and conspicuously more than twice as long as that of the other joints of flagellum, furnished with a good number of moderately long sensory hairs; second joint twice as long as the third ; fourth joint terminates in some setæ, one of which is robust and even somewhat longer than the whole flagellum.—Female : Rather slender, especially flagellum which does not reach the front lateral angle of thorax ; flagellum otherwise nearly as in the male, but with rather few sensory hairs and the terminal setæ short.

Peduncle of antennæ with the penultimate joint conspicuously more than half as long as the terminal one.

Epimera of all thoracic segments with their posterior angles subsimilar, at most produced into exceedingly small processes.

Seventh thoracic legs rather slender ; fourth joint somewhat longer than broad and somewhat shorter than fifth ; both these joints on the lower surface without spines and almost without setæ, those of the margins excepted.

Last abdominal segment has on its upper surface a transverse broad impression, often connected with vestiges of transverse sublateral impressions. Posterior margin very short, less than one-fourth as long as the breadth of the segment, slightly convex, with about nine very distinct saw-teeth, the most lateral pair a little longer than the others ; no marginal spines.

Uropoda unusually small in both sexes ; endopod, when directed parallel with the axis of the animal, far from reaching to the posterior margin of abdomen.

Length of an adult male 5·6 mm. ; of a female with marsupium 5·2 mm.

Occurrence.—This species was established on an adult female and two immature specimens from Cape Lizard, southern end of

Cornwall. Canon A. M. Norman informs me in a letter that in 1903 he took the species at Plymouth. A few years ago the Copenhagen Museum received the adult male described and some small specimens captured at Dennis Head, the most northern point of the Orkney Islands (Mag. sc. C. H. Ostenfeld). In material from Mr. Dollfus I found a single specimen from La Banche, near Le Croisic, on west coast of France.

Remarks.—This small species is easily distinguished from all other European forms, *E. affinis* excepted, by having obsolete or quite minute processes on the epimera of the sixth thoracic segment; it is separated from all species by the very short, serrate posterior margin of abdomen, without movable spines. Figs. 3 *b* and 3 *c* show the second male pleopod and its " appendix," for comparison with the same parts of other species figured in my earlier papers.

Species referred with doubt to Eurydice.

E. pontica, Czerniavsky: " Materialia ad Zoographiam Ponticam comparatam," in ' Transact. of the First Meeting of Russian Naturalists in St. Petersburg,' 1868, 4to (written in Russian), p. 81, pl. vi. figs. 4–6. I have not seen the paper, but quote it from E. v. Martens in the ' Zoological Record ' for 1870. Czerniavsky describes the animal as *Helleria pontica* ; it is from the Black Sea.

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EXPLANATION OF THE PLATES.

PLATE 33.

Fig. 1. *Cirolana gallica*, n. sp.

Fig. 1 *a*. Head, thorax, and proximal part of abdomen, from the right side :
   × 4.
   1 *b*. Left antenna, from below ; × 15/2.
   1 *c*. Seventh left thoracic leg, from below ; × 15/2.
   1 *d*. Last abdominal segment and uropoda, from above ; × 7.

Fig. 2. *Cirolana Schmidtii*, n. sp.

Immature female.

Fig. 2 *a*. Lateral part of thorax, from the right side ; scarcely × 8.
   2 *b*. Seventh left thoracic leg, from below ; × 13.
   2 *c*. Right uropod, from above ; × 13.

Fig. 3. *Cirolana Cranchii*, Leach.

Adult male.

Fig. 3 *a*. Right uropod, from above ; × 8.

Fig. 4. *Cirolana Hanseni*, Bonnier.

Immature specimen.

Fig. 4 *a*. Animal, from above ; × 11.
   4 *b*. Right part of thorax and of proximal part of abdomen, from the side ;
      × 21.
   4 *c*. Second left thoracic leg, from below (from behind) ; × 36.
   4 *d*. Fifth left thoracic leg, from below (from in front) ; × 36.

PLATE 34.

Fig. 1. *Cirolana Hanseni*, Bonnier ; continued.

Fig. 1 *a*. Head with proximal part of antennulæ and antennæ, from above ;
   × 24.
   1 *b*. Anterior part of the head, from below, showing antennulæ, peduncle,
      and proximal part of flagellum of antennæ, eyes, frontal plate,
      clypeus, labrum, and anterior part of mandibles with their palps ;
      × 35.
   1 *c*. Left mandible, from below ; × 50.
   1 *d*. Distal part of left mandible, from above ; × 83.
   1 *e*. Left maxillula, from below ; × 50.
   1 *f*. Left maxilla, from below ; × 50.
   1 *g*. Left maxilliped, from below ; × 50.
   1 *h*. Five proximal joints of left maxilliped, from above, showing the lobe
      from second joint with its single hook and some setæ ; × 50.
   1 *i*. Seventh left thoracic leg, from below (from in front) ; × 36.
   1 *k*. The two posterior abdominal segments with the uropoda, from above ;
      × 22.
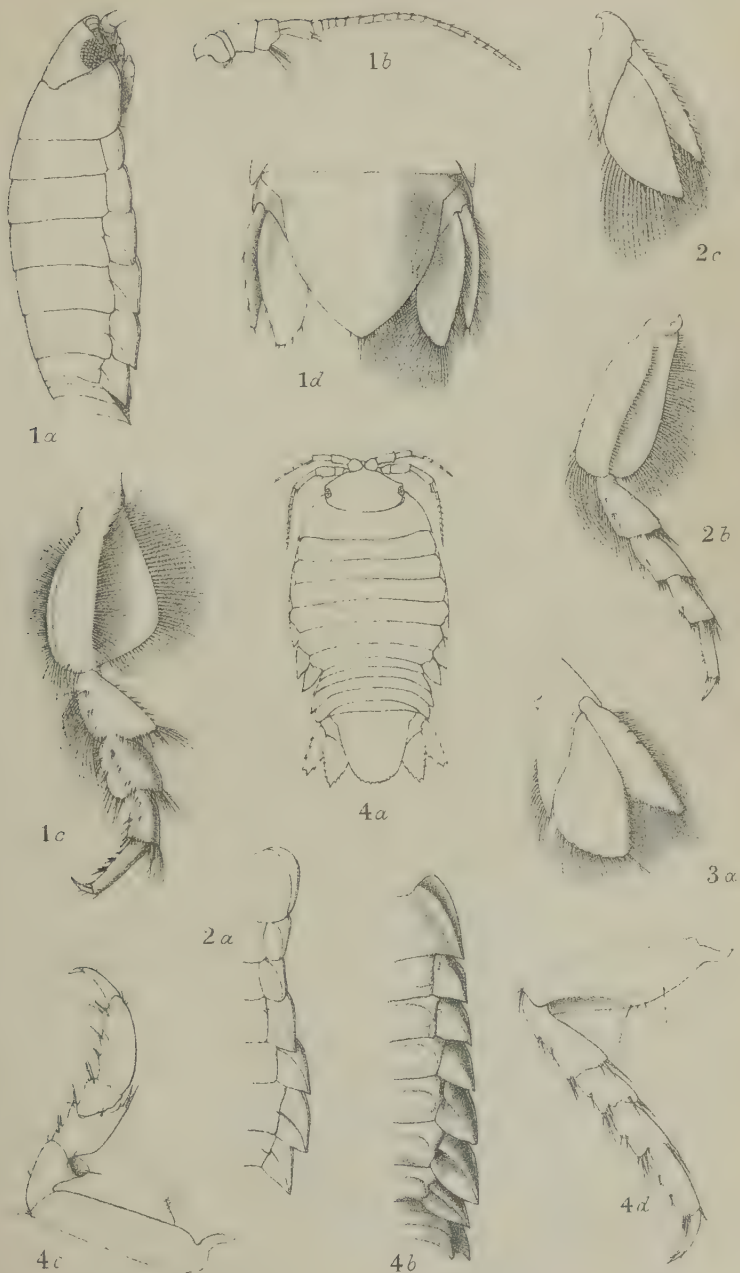
1. Cirolana gallica, n. sp.   2. C. Schmidtii, n. sp.   3. C. Cranchii, Leach.
4. C. Hansenii, Bonn.
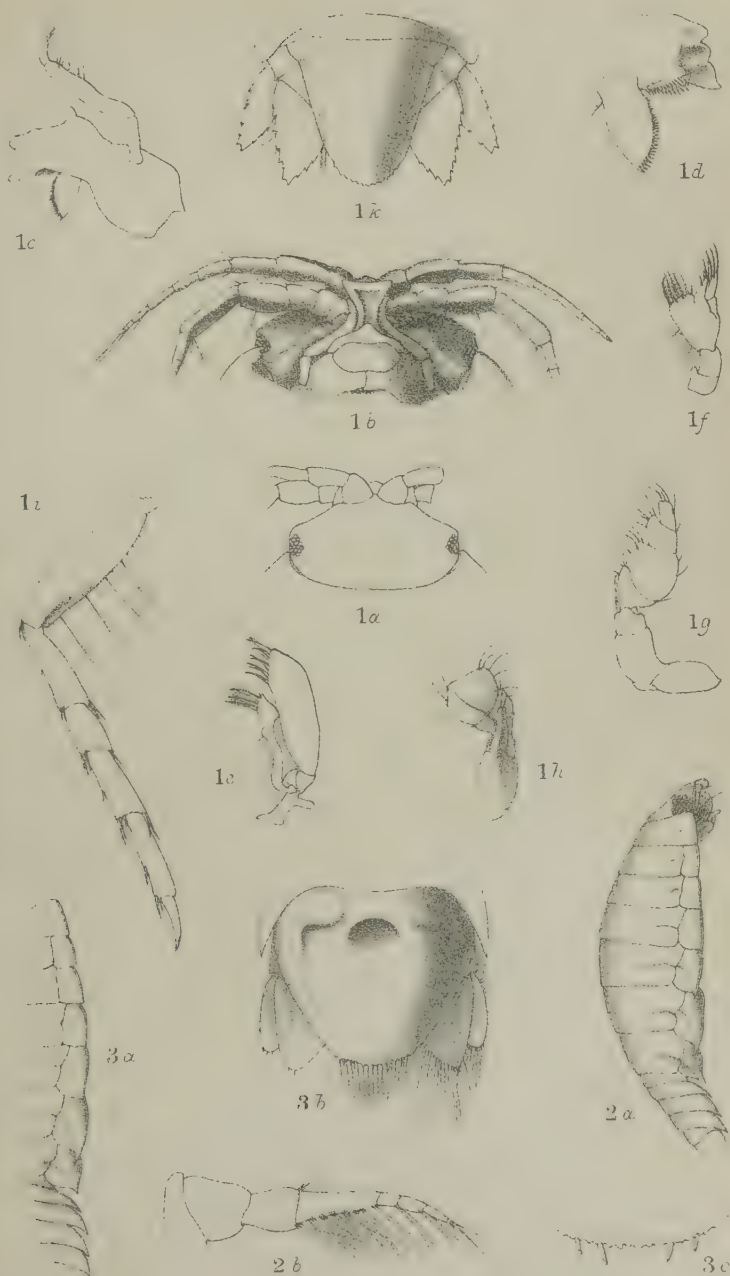
1. CIROLANA HANSENII, Bonn.   2. EURYDICE TRUNCATA, Norm.
3. E. PULCHRA, Leach.
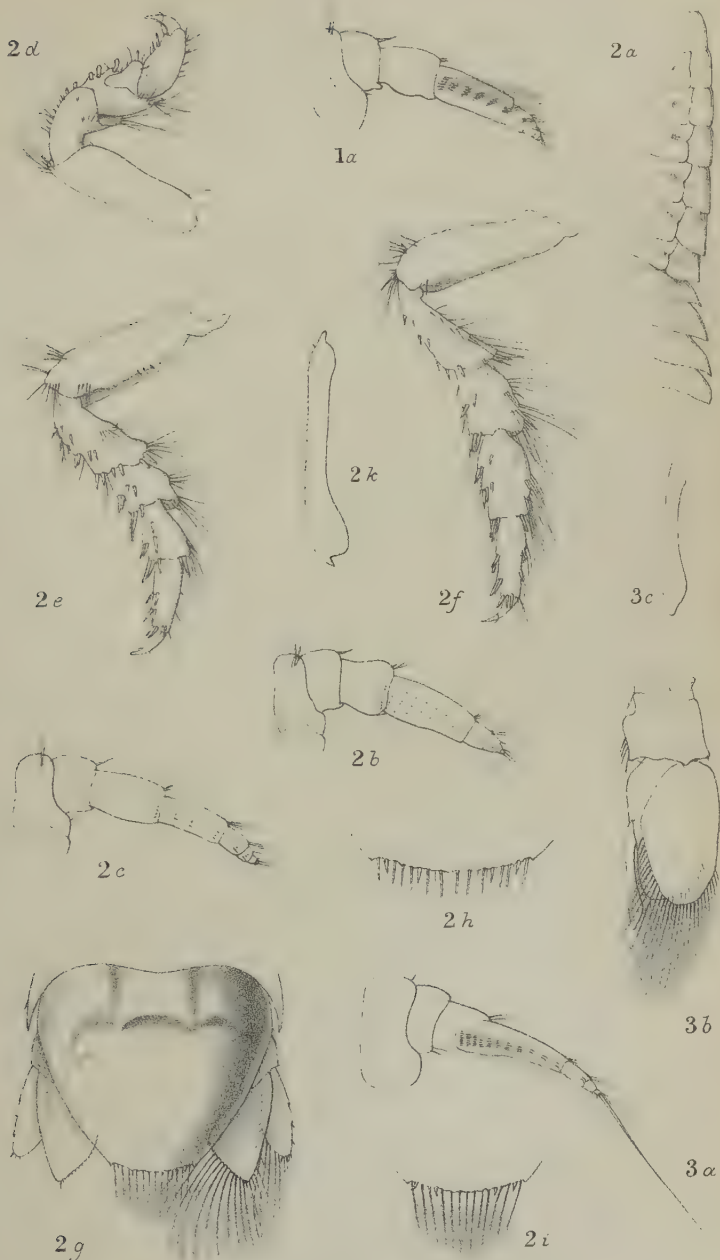
1. EURYDICE PULCHRA, Leach.   2. E. AFFINIS, n. sp.
3. E. INERMIS, H.J. Hansen.

Fig. 2. *Eurydice truncata*, Norman.

Female without marsupium.

Fig. 2 *a*. Head, thorax, and major portion of abdomen, from the right side;
× 8.

2 *b*. Left antennula, from below; × 46.

Fig. 3. *Eurydice pulchra*, Leach.

Large female without marsupium.

Fig. 3 *a*. Right part of thorax and major portion of abdomen, from the side;
× 10.

3 *b*. Last abdominal segment with uropoda, from above; × 21.

3 *c*. Posterior margin of the segment shown in fig. 3 *b*; × 43.   Setæ
omitted.

PLATE **35**.

Fig. 1. *Eurydice pulchra*, Leach; continued.

Fig. 1 *a*. Left antennula of a large female, from below; × 43.

Fig. 2. *Eurydice affinis*, n. sp.

Adult male, and female without marsupium.

Fig. 2 *a*. Right part of thorax and five anterior abdominal segments of the
male, from the side; × 20.

2 *b*. Left antennula of the male, from below; × 59.

2 *c*. Left antennula of the female, from below; × 59.

2 *d*. Second left thoracic leg of the male, from below (from behind);
× 30.

2 *e*. Fifth left thoracic leg of the male, from below (from in front); × 30.

2 *f*. Seventh left thoracic leg of the male, from below (from in front);
× 30.

2 *g*. Last abdominal segment with the uropoda of the female, from above;
× 31.

2 *h*. Posterior margin of the segment shown in fig. 2 *g*; × 60. The four
movable spines are shown, but of the setæ only the proximal part
has been drawn.

2 *i*. Posterior margin of last abdominal segment of the male; × 60.

2 *k*. "Appendix masculina" of second left male pleopod, from below;
× 77.

Fig. 3. *Eurydice inermis*, H. J. Hansen.

Adult male.

Fig. 3 *a*. Left antennula, from below; × 52.

3 *b*. Second left pleopod, from below; × 29.

3 *c*. "Appendix masculina" of second left pleopod, from below; × 40.

A further Contribution to the Study of *Pelomyxa palustris*
(Greeff). By LILIAN J. VELEY (*née* GOULD), F.L.S.

[Read 6th April, 1905.]

(PLATES **36–38**, & text-figure.)

THE freshwater Rhizopod *Pelomyxa palustris* was first described
by Professor Greeff in 1867 as *Pelobius* and later discussed by
the same observer under its present name.

Between 1869 and 1879 his researches were followed by those
of Leidy and Korotneff. In 1891, Prof. A. G. Bourne studied
another species (*P. viridis*) and published his observations on
this and the species in question in the ' Quarterly Journal of
Microscopical Science.' Prof. Bütschli, in 1892, contributed to
our knowledge of the structure of the protoplasm in *Pelomyxa* ;
and later observers, notably Dr. Pénard in 1893 and since, have
published observations of great interest relating to this curious,
and in some respects mysterious, Protozoon. The present
writer, in a paper published in the ' Quarterly Journal of Micro-
scopical Science ' in 1894, brought forward some points with
regard to the minute structure of *Pelomyxa palustris*, together
with some new observations confirming, as far as they went, the
suggestions of Prof. Bourne and Dr Pénard that the rods found
scattered through the protoplasm of *Pelomyxa* were neither
crystals nor protein crystalloids, as had been previously supposed,
but bacteria. Mr. M. D. Hill undertook some culture-experiments
with a view to establishing this, but these had negative results.

The view that the rods are bacteria has, however, found
general acceptance, though no absolute proof has yet been
published. In Dec. 1895 an opportunity offered itself to me for
the further study of this and other questions relating to
Pelomyxa ; investigations were then undertaken, and have been
continued at intervals each year up to 1903. The results of
these investigations are embodied in the present paper, and the
new points which it is hoped thereby to establish, with regard
(1) to the bacteria, (2) to the refringent bodies, (3) to the general
structure and behaviour of the animal itself, are, mainly, as
follows :—

The Bacteria.

(1) The definite proof that the rods are bacteria
       (*a*) by their motility and division,
       (*b*) by their reactions,
       (*c*) by successful culture.
(2) The life-history of the bacteria, in fresh preparations and in culture; and
(3) The identification of these as a new species, which it is proposed to name *Cladothrix pelomyxæ*.

The Refringent Bodies.

(1) The proof that the refringent bodies are proteid in nature.
(2) That they have a definite relation to the bacteria, supplying them (*a*) with a point of attachment necessary for the completion of their development, (*b*) probably also with nourishment.

The Animal as a whole.

(1) Some observations on the nature of the pseudopodia, which tend to show that a recent classification of Rhizopoda based on the characters of the pseudopodia, as hitherto known, will not hold good as regards *Pelomyxa*.
(2) Observations on
       (*a*) the division of a single *Pelomyxa*,
       (*b*) the fusion of a divided portion with the protoplasm of a second *Pelomyxa*.

It will be convenient to consider these points in the order given, taking first

THE BACTERIA.

The true nature of these was first definitely established by me when working in my private laboratory in December, 1895. It had appeared desirable to study *Pelomyxa* not only during the summer months, but also during the winter, if possible, and with this view Mr. Bolton was applied to for a supply of living specimens. He was only able to supply seven individuals, reporting them as "scarce at this time of the year." The first question to which I directed my attention was the motility of the rods, as the fact of motion had always been observed in rods

cast out from the living animal; but Prof. Bourne and others had considered this motion to be possibly molecular, and in my previous observations it had not been possible to satisfy myself absolutely that the motion was not due to currents created in the water by the activity of the pseudopodia, or to other physical causes. The seven *Pelomyxæ* used in this investigation were healthy but sluggish specimens, in which rods and refringent bodies were very abundant and the former unusually large and thick. The method of observation adopted was to crush a *Pelomyxa* in a drop of water, so as to set free the bacteria, and to watch these continuously for periods of several hours without intermission (generally for 3 hours in the morning and 2 hours in the afternoon), without removing the eye from the microscope.

Motility.—The rods, when set free, moved at first actively at the free edge of the animal, gradually becoming more sluggish and eventually coming to rest altogether. As a result of continuous observation directed to this one point only, I was able to establish on the first day that the motion was undoubtedly one of translation. The rods moved even very rapidly at times, in opposite directions and in every direction; the *Pelomyxa* having been killed by crushing, there were now no currents due to motion on the part of the animal; further, the drop was not allowed to evaporate, hence there could be no currents due to evaporation.

The motion of the rods was both horizontal and vertical, and could often be seen to change from one plane to the other; several times a rod was observed to swim vertically and then turn over and travel away horizontally. The motion was of the kind always associated with the presence of flagella, and suggested the presence of flagella at each pole, or possibly all round. While watching a large rod of six joints in one of the " pools " made in the interior of the *Pelomyxa* by crushing, it was seen to swim actively in the pool and then to pass *through* an intervening bridge of protoplasm into a second pool. By focussing the rod carefully during transit it was possible to be certain that it passed *through*, not under or over the protoplasm, and this with a peculiar boring action like that of a bradawl when used to make a hole, viz., a revolution through half of a circle and back.

The attention of other observers was called to the motion of the rods, and all testified that it was transitional.

Having thus established satisfactorily that the rods were capable of independent motion of a bacterial nature, attention was next directed to watching for their division.

Division.—It was fortunately possible, by the same process of continuous observation, to establish the fact of division of a rod. For this purpose, however, periods of 3 hours were not enough; the observation required to be absolutely unbroken for the whole day. My thanks are here due to my husband, who rendered continuous observation possible by taking my place at the microscope when short absences were necessary for meals.

The 28th and 29th of December were spent in this manner, and during these two days I observed division several times, a single rod of course being kept under observation in each case. Division took place in the following manner: a rod consisted of two equal joints A B; A formed a third joint by the appearance of a new constriction dividing it exactly at the middle. At this stage the rod presented the appearance of being divided into one long joint and two short ones. Sometimes the newly-made joints rapidly grew to equal length with joint B before further division, and this accounted for the rods with an odd number of joints (three or five) so commonly found. Sometimes, however, joint B followed suit almost immediately with division, resulting in the formation of a rod with four joints of equal length. In this case history repeated itself, viz., either one of the terminal joints divided again (5 joints), or both terminals did so, producing a six-jointed rod. Now, and now only, so far as I was able to observe, did actual separation take place, a 4-jointed rod breaking in half, or a 6-jointed rod breaking off *two* of the terminal joints *in one piece.*

This appears to be absolutely characteristic of the organism under normal conditions, and accounts for the fact that *free* single-cell rods are, as far as my experience goes, never found; hence the necessity of starting from a two-jointed individual, which at first sight seems not to be beginning at the beginning. This division from a double unit surprised me exceedingly, and I am not aware if such a mode of division has any parallel among known life-histories; however, the fact remains that subsequent investigations only served to confirm the observation, and indeed it afterwards formed an important means of identification.

Once an 8-jointed rod was seen to break off four joints, but in no case was the unit set free a single one. Division was by

no means frequent, and had the periods of observation been less protracted it might easily have been missed.

The actual process was very rapid, occupying about one minute; the rod under observation bent and straightened itself alternately about three or four times, with a lashing movement, and then broke at the point of bending (*i. e.* the second joint from the terminal) and each part travelled away, generally in opposite directions, viz., going, so to speak, original pole first, and showing at that end the slight " halo " which seemed to point to the existence of flagella.

Reactions.—The rods, which may now be definitely called bacteria, stained well with all bacterial stains, notably with Gram, with Heidenhain's iron-hæmatoxylin, and with all the aniline stains.

Almost all known stains for flagella, viz., Loeffler's, Van Ermengem's, Fischer's, Moore's, and very many others, or modifications of these, were applied in the hope of demonstrating the presence of organs of locomotion, but though an appearance suggesting either a bunch of flagella, or a single very thick flagellum, at the poles, often resulted, yet the preparations were never sufficiently definite to satisfy me on this point. It is well known that the flagella of certain bacteria (Fischer, **12**) may be resistant to all but one particular ingredient in the stain, and I have little doubt that the demonstration of these flagella is merely a question of some such ingredient which has not yet been hit upon, or of greater technical skill in the operator. Other possible reasons for the failure to demonstrate the flagella may be (1) the extreme delicacy of these organs, which often causes them to be thrown off in the preliminary process of fixing, or (2) the fact that they may possibly not be permanent structures at all: appearances at times have suggested both these explanations.

Life-history of the Bacteria.

It still remained to follow out the development of the bacteria, and I was ultimately led to success in this undertaking by a very curious and happy accident which occurred in December 1895, while the seven *Pelomyxæ* already spoken of were under observation, and therefore it will not be out of place to describe this occurrence at this point, although it is also closely connected with work on the refringent bodies which is to be discussed later. On Dec. 30, 1895, on going to procure the last two of the *Pelomyxæ* from the glass vessel in which they had been placed, no specimens

were to be seen, but a very large Rotifer was discovered, which had escaped my notice previously, but now attracted it by an unusually milky-white appearance.

The suspicion that the Rotifer had devoured the missing *Pelomyxæ* was confirmed by microscopic examination, and as no more material could then be obtained, it was determined to tease up the Rotifer in water, in the hope of finding the bacteria and refringent bodies in useable condition. This was done, and the contents of the *Pelomyxæ* were found to be practically unchanged. The refringent bodies separated out in the water, and the bacteria were found to be quite alive, and were seen to be attached to the walls of the refringent bodies in great numbers, and to be in active " wobbling " movement on these. Seen " end-on," they presented such a curious and interesting appearance as to induce continued careful study. In the course of $1\frac{1}{2}$ hour's watching a very curious thing happened ; the debris of the Rotifer contained, among other things, a good many Rotifer ova, and the bacteria gradually detached themselves from the walls of the refringent bodies and swarmed upon the ova of the Rotifer instead, and this in such numbers that the ova soon were quite covered and could only be distinguished from the refringent bodies (in the former condition of these) by focussing through to find the nuclei. The refringent bodies were eventually quite deserted, and remained clear and homogeneous. Clearly, then, the ova possessed an attraction for the bacteria, which might be of a purely chemiotactic nature ; but on the other hand the bacteria might be attracted to the ova either as a source of oxygen or as a food-supply. It seemed unlikely that bacteria whose natural habitat was in the interior of living protoplasm should be highly aerobic, and therefore the hypothesis that they regarded the ova as a fresh source of food seemed the most likely. At any rate this was taken as a working hypothesis, and the first conclusion to which it led was that the theory which applied to the ova might also apply to the refringent bodies, and that the long-observed relation between these and the bacteria might be that of food-supply. A second inference drawn from the observation was that, if the bacteria were attracted to feed upon albuminous bodies, such as ova, some form of albuminous liquid would be the proper medium in which to attempt their cultivation ; and further, that some light was now thrown upon the probable composition of the refringent bodies themselves. Subsequent investigation (in

1896) confirmed these conclusions, as will be explained in the
section of this paper dealing more particularly with the refringent
bodies.

Meanwhile, with regard to the bacteria, it was by working on
these lines that it was eventually found possible to follow the
development through all its stages, though it was not until 1899
that success was fully attained.

In the spring of 1896 Mr. Bolton was again applied to for a
supply of *Pelomyxæ*, and 28 individuals were obtained.   These
were chiefly used for work on the refringent bodies, but on
March 13 some rough attempts at cultivation of the bacteria
were made, using as a medium Mann's twice-filtered dilute
solution of egg-albumin in sterilized distilled water.   The albumin,
being drawn straight from the egg, was tolerably germ-free, and
was put into a sterilized tube, to which a *Pelomyxa*, teased up
with a sterilized needle, was added, and the tube closed with
sterilized cotton-wool, and placed in the same temperature as
the vessel containing the supply of living *Pelomyxæ*.

On March 16 the tube was removed to a slightly warmer tem-
perature.   In a few days a white filamentous growth was seen to
be proceeding from one of the teased-up portions of *Pelomyxa*
in the tube, and on microscopic examination was found to consist
of a pseudo-branching system, attached to one of the refringent
bodies, containing rods in a single-walled sheath, which broke
down, while under examination, to form free bacilli.

A preparation was made of this, but, owing to the nature of
the medium in which the growth was formed, the preparation
showed too much stained deposit around the filaments and rods
to be instructive.   At the time, also, not much importance was
attached to this development, owing to the fact of the albumin
not having been sterilized ; the growth was regarded as probably
belonging to the common species of *Cladothrix* (*C. dichotoma*),
which might have been ingested by the *Pelomyxa,* and con-
sequently as vitiating the experiment.   It was not realized until
later that the actual development sought for had probably
been accidentally obtained.

Further experiments at this time gave negative or mixed
results, and were beset with the difficulties, formerly experienced
by Mr. Hill, of properly sterilizing the animal itself, as well as
the impossibility of satisfactorily sterilizing by heat a coagulable
medium

The years 1897 and 1898 had to be entirely devoted to another bacteriological research, published in 1898, and it was not, therefore, till the spring of 1899 that attention could again be given to the study of *Pelomyxa*.

In April 1899 the interesting discovery was made at the University Museum, Oxford, of a very large quantity of *Pelomyxa palustris* in a tank in the grounds of the Department of Comparative Anatomy, and my best thanks are due to the Linacre Professor for his great courtesy and kindness in not only placing at my disposal what was practically an unlimited supply of material, but affording me an opportunity of working at this in his laboratory, where most of the following research was accordingly carried out. It may be interesting to note that the colony in the tank must almost certainly have originated from stray individuals accidentally emptied into this tank by me during my researches as a student under Prof. Lankester in 1893. The specimens now found were full-fed healthy individuals, and most were of unusually large size, and contained abundance of rods and refringent bodies : they were generally of a dirty olive-green tint, which, though probably due to food, was found to be characteristic of all really healthy specimens ; only starved or sickly ones ever exhibit a milk-white appearance.

It was now determined to undertake a fresh series of culture experiments, side by side with more elaborate study of the bacteria in a great number of fresh preparations, and, if possible, to check the cultures by comparison with stages which might be discovered in the fresh preparations. It appeared that only in this way could one be certain of the correctness of results obtained in culture, as an insuperable difficulty to complete sterilization presented itself during the study of this batch of *Pelomyxæ*. This was the fact, not sufficiently realized either by myself or Mr. Hill on previous occasions when we had only a few individuals to work with, that even if complete sterilization of the outside of a *Pelomyxa* could be effected, a number of bacteria other than the rods in question were always present in the interior of the animal, having been ingested with the food, and these could not possibly be eliminated without killing the rods. Fortunately for the experimenter, these accidental bacilli did not at all closely resemble the rods, being very much finer and thinner ; therefore there was no difficulty in identification under the microscope.

The theory I had formed was that single rods might settle

upon refringent bodies as a support, possibly also deriving food from them ; if this were the case, it ought to be possible to find some evidence of it, if a sufficiently large number of *Pelomyxæ* could be examined.

After the examination of a great many fresh preparations, in which *Pelomyxæ* were teased up in water and their contents carefully studied, I was fortunate enough to obtain one in which several single filamentous growths occurred, each attached to and springing from one refringent body. They were composed of a single rigid slightly-curved chain of jointed rods exactly similar to the characteristic jointed rod of *Pelomyxæ* ; the joints, of which there were 20–30 in a single growth, were of the same thickness and length as the free rods and stained in a precisely similar manner, leaving the fine single-walled sheath colourless and barely visible.

They are figured in Pl. **36**. figs. 1, 2, which are reproduced from photomicrographs by Dr. G. Mann. One or two showed pseudo-branching (fig. 1). Later on in the course of my researches, a fully-developed pseudo-branching filamentous growth, attached by its base to a single refringent body, was teased out of a fresh *Pelomyxa* and is figured on Pl. **36**. fig. 4. Also on several occasions a live *Pelomyxa* under observation was seen to eject a complete branched system of this kind, the effort to get rid of so large and rigid a body often resulting in the " bursting " or disintegration of the animal.

The branched systems so ejected ultimately broke down to form 2-jointed free rods. A preparation was made of one such ejected growth, which exactly resembled those previously described and figured, and stained well with iron-hæmatoxylin. It seemed clear that I had obtained two of the later stages of development, but the earliest stage, viz., the free unit fixing on a refringent body, had not as yet been found. The observations were extended to a great number of *Pelomyxæ* in the hope of finding this also, and eventually success was attained.

In a teased preparation a single 2-jointed rod (double unit) was seen to fix itself by one end to a refringent body. A minute " blob " of secretion appeared to be formed at the point of attachment, which fixed the rod firmly to its support. (Pl. **36**. fig. 5.)

Later, other rods were observed to fix in the same way.

Any slight jolt or vibration occurring before the secretion had become firm was sufficient to dislodge the bacillus, but at a later

stage it appeared to be rigid, and was then much more resistant to shocks of this kind. Having once secured the fact that the bacilli did so fix themselves, I isolated several 2-jointed rods with a few refringent bodies in a drop of water sealed from evaporation by means of soluble glass, and these without exception fixed themselves upon the bodies, but they did not grow, remaining quite stationary as to size and number of joints.

More advanced stages (three and five joints) obtained in other fresh teased preparations are, however, seen on Pl. **36.** figs. 6, 7, rendering it evident that under normal conditions growth took place after fixation, for no rod of greater length than the double unit was ever seen to fix itself. Proof of this growth was finally obtained by isolating 2-jointed rods and refringent bodies from a fresh preparation in a hanging-drop of Mann's dilute solution of egg-albumin, when growth occurred, and the rod under observation attained 5 joints, but never developed fully, owing to the highly artificial conditions. Three stages of such growth, as drawn at intervals of 24 hours for three days, are seen in Pl. **36.** figs. 8–10. A difficulty was, however, experienced at this stage of the work which unfortunately necessitated my transferring it to another place. The floor of Prof. Weldon's laboratory was found to vibrate so much that the commotion caused in a drop by a passing footstep was sufficient time after time to dislodge bacilli in an early stage of fixing. By the kindness of the Waynflete Prof. of Chemistry I was, however, enabled to set up my apparatus for the hanging-drop cultures above described in a ground-floor room of his department at the University Museum, on a balance-table built up from the foundations, where the vibration difficulty was entirely overcome and success attained.

A number of cultures were now undertaken, but owing to the difficulty of sterilizing egg-albumin, it was suggested to me to use serum-albumin as the medium. Dr. W. Ramsden, of the Physiological Department at the University Museum, kindly provided me with some fresh sheep's serum, which I sterilized by sucking it through a Muncke's filter by means of a vacuum-pump into sterilized flasks which were closed with sterilized cotton-wool. Two *Pelomyxæ*, which had been kept hungry in clean water, in order to minimize as far as possible the danger of contamination from their contents, were then cleansed externally as far as possible by washing them successively in eight vessels of sterilized distilled water. They were then thoroughly

teased up with sterilized needles and " planted," one in each flask, and both were placed in the dark at room-temperature.   Both flasks gave abundant growths, of course of a mixed character. From these fresh cultures were made in the same medium, selecting as far as possible those large rods which were identifiable as characteristic of *Pelomyxa*; and this process of selection and re-selection was repeated constantly until an approximately pure culture was obtained (Pl. **36.** fig. 3.)

From this nearly pure culture two more flasks were inoculated and gave growths of rods resembling those of *Pelomyxa*, and stainable in the same manner; also a hanging-drop of egg-albumin, containing a few refringent bodies, was inoculated from the pure culture and gave results exactly similar to that inoculated with rods from the fresh preparation above described (Pl. **36.** figs. 11–13).

From a comparison of these figures it will be admissible to consider the growths as identical. In the drop the rods had fixed on the refringent bodies; in the flasks they fixed both on refringent bodies and on the walls of the flask, and, growing very slowly, attained a considerable length, but in neither culture did they show at this time any sign of branching.   After a growth of a fortnight, they exactly resembled those unbranched filaments first discovered in *Pelomyxa* growing on the refringent bodies.

At this time I was obliged to be away from home for six weeks, leaving a pair of flasks with cultures two weeks old in the condition described.   When I returned, I found that the filaments in these cultures had branched, and that the branching was of the pseudo-dichotomous kind previously observed in the fresh preparations, viz., either the kind of apposition commonly known as peculiar to the genus *Cladothrix*, or that early stage of it, a dichotomous branching of the *sheath only*, which has been figured by Fischer for *Cladothrix* (Pl. **37.** figs. 14–16.)

From the nature of the medium in which the filaments were grown, it was almost impossible to make a satisfactory permanent preparation of them.   But it seemed so desirable to preserve some evidence of the branching that my friend Dr. Gustav Mann, who was consulted with regard to this, kindly attempted to make a preparation for me of the bacteria from the serum by a special method of precipitating them.

His ingenuity produced a fairly successful preparation, sufficient to show the point in question, although the method

used created a crinkled and unnatural condition of the filaments.
The filaments in the other flasks, which contained older cultures,
had, on my return, already broken down to form short rods, so
that the cycle had been completed without my being able to
state at exactly what period this breaking-down had taken place.
It will be seen, however, that the stages observed in (1) the fresh
condition, (2) in cultures, were five in each, and that, as the
following table shows, the stages in (1) were exactly parallel and
similar to those in (2) and may fairly be considered identical.

Fresh Preparations.	*Cultures.*
Stage 1. Motile 2-jointed rods (units).	1. Motile 2-jointed rods.
„ 2. Fixing of unit on refringent bodies.	2. Fixing on solid bodies.
„ 3. Growth to form long filaments.	3. Growth to form filaments.
„ 4. Pseudo-branching of filaments.	4. Pseudo-branching of filaments.
„ 5. Breaking-down to form short rods.	5. Breaking-down into short rods.

Although the circumstances of this case necessitated a mode
of procedure necessarily less exact than that justly demanded in
most bacteriological experiments, yet the above stages which
have been observed and recorded form a complete cycle of
development; and the conclusion reached must surely be, that the
life-history of the bacteria characteristic of *Pelomyxa* has been
placed beyond reasonable doubt.

Identification of the Bacteria.

The classification followed is that of Migula. The order is
that of Eubacteria. From the character of the sheathed filament,
and the reproduction by "swarmers" set free and immediately
recommencing the cycle, the bacteria of *Pelomyxa* belong to the
family Chlamydobacteriaceæ.

From the single contour of the walls of the sheath, from the
equal size of the filament from base to tip, and from the pseudo-
dichotomous branching, the bacteria belong to the genus
Cladothrix, Cohn=*Sphærotilus* (Kützing, Mig.). Only two
species of this genus are known—viz., *Sphærotilus dichotomus*
(*C. dichotoma*, Cohn), and *Sphærotilus natans*, Kützing. The
species in question differs from both in one important particular,
viz.—the free rods or swarmers of *Pelomyxa* are straight and
always most distinctly and sharply truncated at the ends,

whereas the swarmers of *C. dichotoma* often slightly tend to be
kidney-shaped and are always rounded at the poles; the
swarmers of *S. natans* are also slightly rounded at the ends. ,
Both these species occur as tufts composed of several filaments
whether fixed or free; the bacteria of *Pelomyxa* appear to occur
exclusively as single filaments. In size the rods agree fairly
with either species, the average thickness being 2μ. They
resemble *S. natans* very closely in the slight separation of the
cells in the filament from each other (shown very distinctly in
stained preparations); but differ in the fact of the *free* unit
always being double and in the greater rigidity of the filament as
a whole. The habitat must be taken into consideration, with
the fact that, as far as my search went, neither of the known
species of *Cladothrix* occurred in the tank whence the greater
number of *Pelomyxæ* were taken; and, further, that as far as our
knowledge extends at present, there is no evidence that the
bacteria of *Pelomyxa* can live for any length of time apart from
their host. On the whole, then, it seems justifiable to regard them
as a new and distinct species of *Cladothrix*, which it is proposed
to name *Cladothrix Pelomyxæ*, and to classify as follows:—

> Order, EUBACTERIA.
> Family, Chlamydobacteriaceæ.
> Genus, *Cladothrix*, Cohn; *Sphærotilus*, Kützing.
> Species, *C. Pelomyxæ*.

THE REFRINGENT BODIES.

Some reactions of the refringent bodies had been tested by
Greeff and others, but further experiments were made in the
course of the present investigation. They were tested for starch
with a very dilute solution of iodine, but gave no reaction
whatever. (With *strong* iodine a brown colour was obtained, as
previously recorded by Greeff.) Starch was therefore excluded.
Paramylum is unstained by dilute iodine, hence the refringent
bodies were next tested for this; their behaviour with strong
sulphuric acid also suggested a similarity, but their resistance to
dilute potash excluded paramylum. They were also compared
with the concretions in *Lithamœba*, as studied by Prof.
Lankester; the reactions were found very much to resemble
those recorded for *Lithamœba*.

The occurrence above related in connection with the bacteria
and the ova of Rotifer now gave a new direction to experiments.

With a view to ascertaining whether the bodies were albuminous, or albuminoid, almost every known micro-chemical test for albumins was applied; these tests are not numerous, and most are not decisive, but were found to give the reaction, said to be characteristic, equally well with the refringent bodies and with almost anything else, *e. g.* the fingers of the operator, and even with blotting-paper. The most reliable, however, appeared to be (1) that with Millon's Reagent, (2) the violet reaction with sugar and sulphuric acid, (3) the xanthoproteic test, and (4) that with caustic soda and copper sulphate. As far as my control experiments went, none of these gave the reaction with wrong substances.

The Nature of the Refringent Bodies.

The effect of these reagents as applied to the refringent bodies was as follows, used on freshly-teased up *Pelomyxæ* taken from water. On application of Millon's reagent there was no staining at first, either of the protoplasm or of the refringent bodies. Then a milky precipitate occurred, with coagulation of the protoplasm, followed by the appearance of a yellowish tinge, and the gradual disintegration both of the protoplasm and the refringent bodies; the latter collapsed, became nodular (Pl. **37.** fig. 17), and ultimately dissolved. On warming, an hour after the addition of the reagent, a delicate pink colour was observed in the refringent bodies, and also in the protoplasm, vanishing on cooling. If heat was applied *immediately*, a deep pink colour was obtained, but the bodies dissolved almost at once. Heating immediately, but less strongly, gave a good pink colour, and the refringent bodies only gradually disintegrated into nodules and disappeared. The depth of colour evidently depended upon the degree of heat applied immediately, but, if heated over a certain point, the destruction of the bodies was too rapid to allow of the reaction being observed.

With strong sulphuric acid the refringent bodies were dissolved; sugar solution, run in afterwards, gave a very distinct, but pale, violet coloration of the liquid.

Strong nitric acid coagulated the protoplasm and shrivelled everything up, but gave a pale yellow colour on heating, deepening slightly on addition of ammonia. A 1% solution of caustic soda, followed by a very dilute solution of copper sulphate, gave no violet coloration even on heating.

The reactions with three out of four tests were, then, perfectly definite, and the conclusion reached was that the refringent bodies are certainly proteid in nature, and are probably some form of albumin, the product of metabolism in the protoplasm of the animal.

It may be mentioned that the reaction with picric acid in turpentine described in my previous paper in the 'Quarterly Journal of Microscopical Science' is consistent with those obtained as above, since the peculiar "bright crescentic areas" produced in the refringent bodies by that stain only, may have been the "local bead-like coagulations" said to be given when crystals of picric acid are dissolved in solutions containing albumin.

The Relation of the Refringent Bodies (a) to the Bacteria, (b) to Pelomyxa.

(*a*) That the refringent bodies certainly afford to the bacteria a point of attachment without which the cycle could not be completed has been already explained. It seems, however, most probable that the relation is a twofold one, and that the refringent bodies serve them also as a food-supply. For the bacteria are found to settle upon the refringent bodies in numbers, in preference to other solid bodies of which plenty are always accidentally present in the protoplasm of *Pelomyxa* ; growth has been proved to take place while this relation continues : further, the facts that the bacteria swarmed upon the albuminous ova of Rotifer in exactly the same manner as on the bodies, and that they have been proved to live and flourish in albuminous media, lend great support to this view.

(*b*) The relation of the refringent bodies to the *Pelomyxa* as a whole is extremely difficult to determine, and must perhaps remain an open question. Two views are possible, and either is rather plausible :—(1) the refringent bodies may be a reserve food-supply to the animal itself ; in this case one would expect it to be drawn upon when other food was unobtainable. Several experiments were undertaken with the object of testing this : many *Pelomyxæ* were kept in clean water without mud or food of any kind, but none survived more than a few days, and in these the refringent bodies were *not* diminished in size ; in control experiments in which *Pelomyxæ* were kept in clean

solutions of egg-albumin without mud, they lived well and divided—a result which might cut both ways.

If, however, the bodies act as a reserve food-supply to *Pelomyxa*, it must be a distinct disadvantage to the animal to have an almost unlimited number of bacteria drawing upon the same supply, and thus we should be left without any explanation of the relation of the bacteria to the animal. It would also be inexplicable that *Pelomyxa* should constantly eject refringent bodies, as it normally does.

(2) A second view, viz., that the refringent bodies are a waste product of metabolism, useless to the animal, seems, therefore, more tenable. In such a case the presence of the bacteria would be perfectly explicable, as they would be of direct advantage to the animal in clearing off useless products, while the proved ejectment by *Pelomyxa* of the bacteria, when the branching system became so large and rigid as to be inconvenient, would also be an advantage to the bacteria, in enabling them to scatter their swarmers so as to be ingested by fresh hosts with the mud of their habitat.

The condition of the resting or quiescent *Pelomyxæ*, which had filled themselves up with sand, described in my previous paper, is very consistent with this view ; for in some of these the refringent bodies were very few and very small, and in others practically non-existent, and the bacteria were equally scarce. This suggests that metabolism not being then active, no waste products were being formed and no scavengers were required ; of course it might also mean that the reserve supply had been already exhausted, but if that were the case it is difficult to imagine what the animal could subsequently have been living upon.

Taking all the circumstances into consideration, the view of the writer is that the refringent bodies are waste products of the metabolism of *Pelomyxa*, and that they serve in a double sense for the support of the symbiotic bacteria.

The Animal as a whole.

Several points of interest as to the general behaviour of *Pelomyxa palustris* were brought out in the course of these investigations : the first of these refers to the character of the pseudopodia, which are generally described as lobose and blunt.

This appeared to me, from a study of many individuals, to be only the case when the animal is sluggish or creeping very quietly; at such a time the contour is certainly perfectly even, and the pseudopodia are as described, showing the hyaline border very clearly (Pl. **37**. fig. 18). Under circumstances equally normal, but inducing greater activity, as when a portion is constricted off naturally, or the animal is getting rid of a large solid or rigid body, the contour frequently becomes temporarily quite ragged, and whip-like pseudopodia of exceeding fineness are shot out with great suddenness and velocity, extending to a considerable length (p. 391). Pseudopodia of this kind are exceedingly attenuated and acute, and are, for a great part of their length from the tip inwards, perfectly hyaline, appearing to be actual prolongations of the hyaline border; they often, but by no means always, radiate outwards, and very frequently anastomose, the connecting bridge between two pseudopodia being sometimes hyaline (p. 391, *A*), but more often consisting of fine strands of granular protoplasm (p. 391, *B*). They are never rigid, and often fall into the most graceful curves. When one of these fine pseudopodia is in course of being retracted, a very curious feature is observable, viz., a peculiar wrinkling of the granular part of the protoplasm, as if it were a soft coating to an elastic core (p. 391, *C*), yet no such actual distinction can be microscopically detected, although the withdrawal of a pseudopodium is a far slower process than its extension.

This observation would appear somewhat to vitiate the classification of Rhizopoda recently proposed by Professor G. S. West, which is founded chiefly on the nature of the pseudopodia, and in which it is stated that those of the order Amœbœa, to which *Pelomyxa* is assigned, are "rarely attenuated and acute, sometimes branched, but never reticulate." It appears to the writer that pseudopodia in general are too transient characters on which to base a classification, and that those of *Pelomyxa* in particular do not agree with the description proposed by Prof. West in his interesting paper.

Prof. West's suggestion that the "characters of the nucleus" in Rhizopods are "of much less importance in these animals than might at first be imagined" was borne out as far as my experience went. In the many experiments made by me with living *Pelomyxæ* in nutrient fluids, when they very commonly divided, the nuclei were always examined for any characteristic

appearance at the time of division, but they were always in a
" resting " state, and presented no appearance suggesting that
they initiated or took an active part in division.

Division, whether affecting only a small portion of the animal,
or one-third or one half, appeared to be always of the same simple
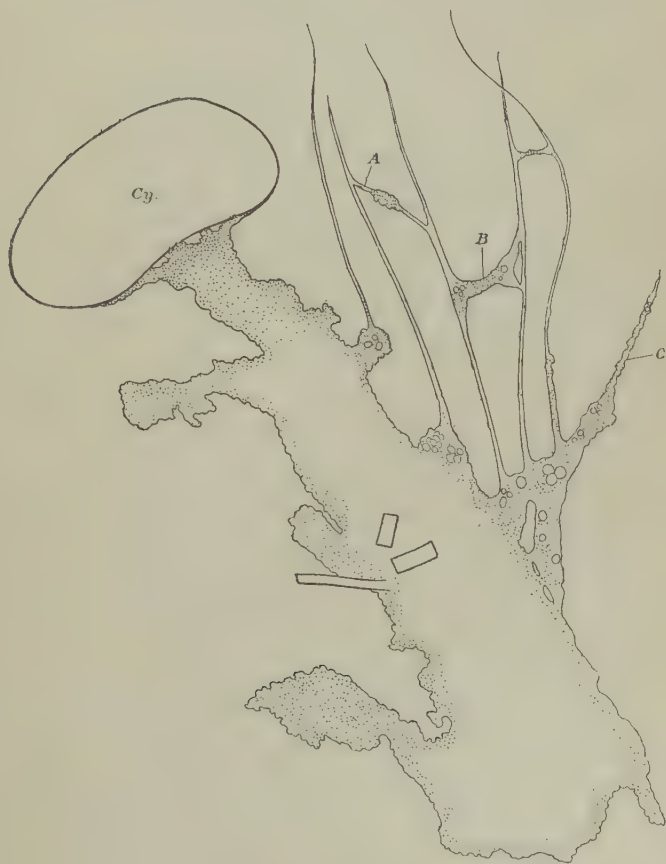
Pelomyxa palustris extruding *Cypris*-shell, with production of acute whip-
like pseudopodia. *A*, hyaline connecting strand; *B*, granular do.;
C, pseudopodium in the act of retraction; *Cy.*, *Cypris*-shell.

character, and generally to be induced by unfavourable
conditions, such as drying-up of the liquid surrounding the
animal; the fragments form perfect individuals in quite a short
time, and obviously several small individuals would have a better

chance of survival under unfavourable conditions, or in a
diminished supply of water, than a single large one.   Large
individuals have a tendency to burst, and I am in agreement with
Pénard's latest view (1902) that this is a quite frequent and normal
occurrence, and not due to surface tension or damage.   Once,
in the whole course of the investigations, a single torn and
damaged *Pelomyxa*, " planted " in a flask of egg-albumin
stoppered with sterilized cotton-wool, gave rise to a very large
number of amœbæ, each possessing a single nucleus and con-
tractile vesicle ; but as this production unfortunately did not
take place under actual observation, the fact only can be recorded.
Such observations have been made before, by Greeff and
Korotneff, but in view of their scarcity, and the fact that they
have never received general acceptance, it seems worth while to
note this, and also to mention that the circumstances excluded
all possibility of any other origin for the amœbæ, with which
the liquid literally swarmed.   Pénard has noted a similar occur-
rence, since Greeff and Korotneff.   One other curious point
must be recorded.   Section had been made of two *Pelomyxæ*
into two pieces each, and these four fragments A^1, A^2, of one
individual, B^1, B^2, of another, were watched under the microscope
in one field, those belonging to one individual being kept on the
left, the others on the right.   (This was being done with a view
to observing whether the ragged pieces rounded up again as
separate individuals, as noted by Pénard for *Difflugia*.) A^1
constricted off a further piece A^3 ; A^3, after complete separation
from A^1, made independent movements, and in so doing
approached B^1.

A^3 and B^1 came into contact, and A^3 immediately fused with
B^1, becoming in a few moments quite indistinguishable from it
(Pl. 38. figs. 22–24).   A similar behaviour of fragments has been
recorded by Pénard for *Difflugia*, but he expressly stated that,
while a fragment readily fused with another *recently severed*
fragment *from the same individual*, no such thing ever occurred
between fragments from different individuals.

This observation with regard to *Pelomyxa* appears, therefore,
to be new, and may possibly have considerable significance, since
it raises the old question whether *Pelomyxa* can ever justly be
regarded as a single individual.   Of course it may simply mean
that the protoplasm of *Pelomyxa* is chemically homogeneous to
an extraordinary degree ; but, on the other hand, if fusion of

individuals, or parts of individuals, takes place at all in nature, it would appear that *Pelomyxa* should rather be regarded as a plasmodium. The single nucleus observed in the amœbæ and the multinucleate condition of *Pelomyxa* are facts consistent with such a theory.

Summary and Conclusions.

The conclusions arrived at in this investigation may, then, be briefly summarized as follows :—

(1) The rods are symbiotic bacteria, which complete their development within the protoplasm of *Pelomyxa* and are then ejected, breaking down into free " swarmers," which are ingested by other *Pelomyxæ*, and recommence the cycle.

(2) The refringent bodies are proteid in nature ; they consist of some form of albumin, which is probably a waste product of the metabolism of *Pelomyxa* ; they have a twofold relation to the bacteria, supplying them with a point of attachment necessary for their development, and (probably) also with a source of nourishment.

(3) The pseudopodia of *Pelomyxa* are not always blunt and lobose, but often exceedingly attenuated and acute, are often reticulate, or anastomosing, and of a different character from any hitherto described for this animal. Classifications based on the lobose nature of the pseudopodia are hereby invalidated.

(4) The division of *Pelomyxa* is of a simple character, in which the nuclei do not play an important part. The only other form of reproduction observed has been, in a single instance, the production of amœbæ, whereby the observations of Greeff and Korotneff are partly, and those of Pénard entirely confirmed.

(5) Under certain circumstances a portion of one *Pelomyxa* may fuse with the protoplasm of a portion of a second *Pelomyxa*, the inference from this observation being that it may prove necessary to regard *Pelomyxa* as a plasmodium.

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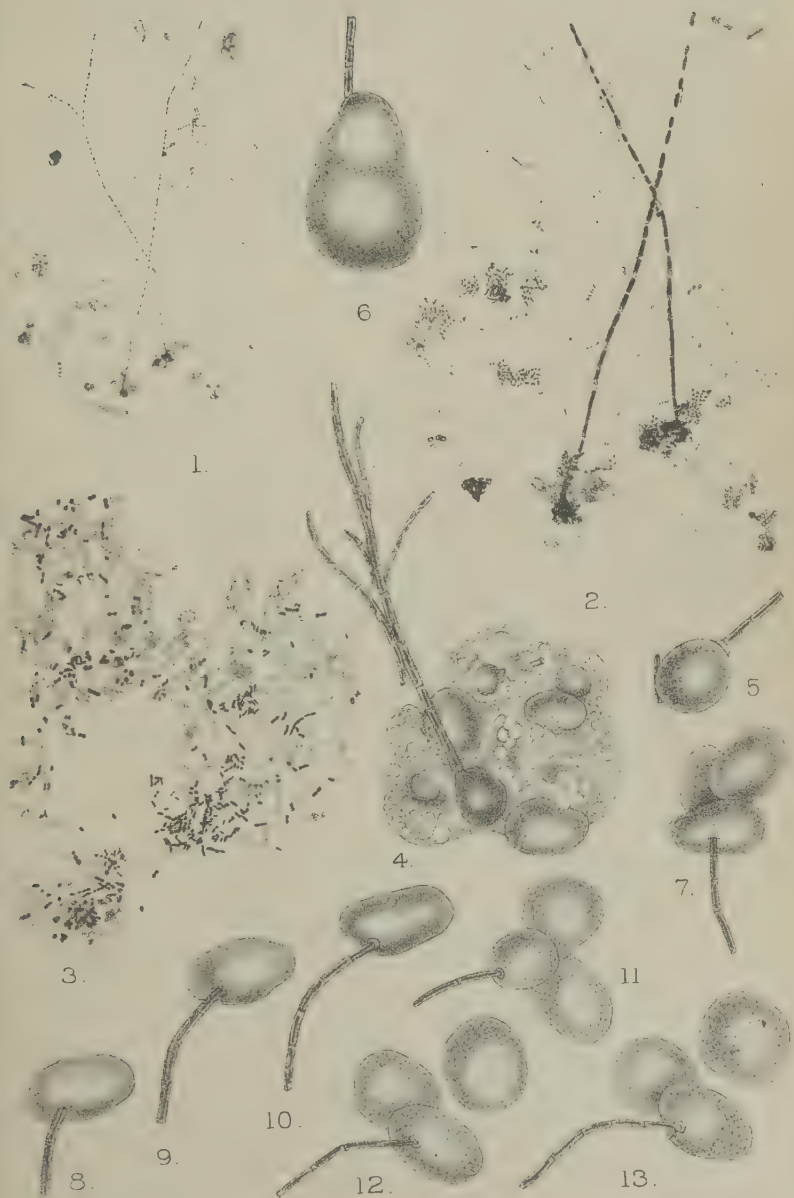
PELOMYXA PALUSTRIS.

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PELOMYXA PALUSTRIS.

PELOMYXA PALUSTRIS

EXPLANATION OF THE PLATES.

(Magnification 1000 diameters, except where otherwise specified.)

PLATE 36.

Fig. 1. Filaments as outgrowths from refringent bodies.   Stained safranin ; magnification about 300.

    2. Proximal portions of the same two filaments.   × 1000.

    3. Rods in culture used as starting-point.   About × 500.

    4. Fully-developed pseudo-branching system attached to refringent body (fresh preparation).

    5. Two-jointed rod fixed on refringent body (fresh prep.).

Figs. 6–7. Three- and five-jointed rods on refringent bodies (fresh prep.).

    8–10. Three successive stages in development of single rod, in drop-culture inoculated from fresh prep.

    11–13. Three successive stages in development of single rod, in drop-culture inoculated from culture.

PLATE 37.

Figs. 14–16. Pseudo-branching filaments from culture 8 weeks old.

Fig.   17. Nodular appearance presented by refringent bodies after treatment with Millon's reagent.

Figs. 18–21. *Pelomyxa palustris* dividing off three successive portions, in egg-albumin ; normal simple division.

PLATE 38.

Figs. 22–24. Division, and subsequent fusion with another individual.

        (1) A^1 dividing-off a portion A^3.

        (2) A^3 independent, approaching B^1, a portion of second *Pelomyxa*.

        (3) Fusion of A^3 with B^1, and withdrawal of A^1.

Notes on a Skeleton of the Musk-Duck, *Biziura lobata*, with
Special Reference to Skeletal Characters evolved in relation
to the Diving Habits of this Bird. By W. P. PYCRAFT,
A.L.S., F.Z.S.

[Read 15th June, 1905.]

(PLATE **39**.)

THE following notes on the skeleton of a Musk-Duck (*Biziura
lobata*), kindly submitted to me for examination by Prof. C.
Stewart, F.R.S., of the Royal College of Surgeons, will, it is
hoped, prove of some service, since no similar description has
hitherto been published, although several short incidental
references are to be found scattered here and there among the
papers of Beddard and others.

The Musk-Duck (*Biziura lobata*) is a native of Australia and
Tasmania, and appears to frequent indifferently large lakes, as
well as the open sea. An expert diver, it seldom, if ever, it is
said, flies in the daytime, though it will do so at night. The
Musk-Duck is generally regarded as the close ally of the genera
Thalassiornis, Nomonyx, and *Erismatura*—making 10 species in
all—mainly on account of the fact that all are remarkable for
the peculiar structure of the tail-feathers, which are long and
stiff, hence they are known as " stiff-tailed " ducks. The nearest
allies of this small group appear to be the Scaups and Pochards.

Of the Stiff-tailed Ducks—the Erismaturinæ of Count
Salvadori—*Biziura* is to be regarded as the most highly
specialized member, adaptation tending to increase the diving
powers of this bird, having effected several noteworthy changes
in the skeleton.

THE SKULL.

This, in the specimen submitted to me, was not fully anchy-
losed, all the cranial sutures are obliterated, but the elements of
the upper jaw remain distinct; and these display one or two
features demanding notice.

The nasal is a somewhat remarkable T-shaped bone. The
frontal process is very long, and extends backwards as far as the
middle of the orbit as a spatulate plate; the premaxillary process
is rod-shaped, and extends forwards as far as, and beneath, the

nasal process of the premaxilla. The descending process forms a linguiform plate apposed to the outer surface of the maxilla. This bone differs from the typical nasal in that the descending process is placed at right angles, instead of obliquely, to the premaxillary process (Pl. **39.** fig. 1).

The *premaxilla* is unusually short and very broad ; its extreme tip has been broken off. The inferior surface of this bone is unusually dense, and is not pierced by foramina as is usually the case among the Anatidæ. The aperture of the anterior nares is of great size.

The *maxilla*, partly on account of the relatively small size of the premaxilla, is very largely exposed. The palatine processes are oblong in shape, of considerable size, and, in this specimen, touch one another in the middle line by their postero-internal angles, leaving a large palatine vacuity. The maxillary antrum is shallow.

The quadrato-jugal bar recalls that of the Mergansers and of *Somateria*, in that it turns abruptly upwards to articulate with the quadrate. This is due to the fact that the glenoid cavity or the quadrato-jugal has shifted so as to be nearer the squamosal head of the quadrate.

The *lachrymal* is free and triangular in form, having the descending process long, slender, and curved backwards. The orbital and nasal processes are not well-defined, blending insensibly with the descending process : the orbital process bears a small tubercle near its free end.

The *frontals* are extremely narrow in the orbital region and bear shallow grooves facing outwards from the supra-orbital gland. Anteriorly they are widely separated so as to expose the mesethmoid when the nasal processes of the premaxilla are raised.

The *parietal* region of the skull—the fronto-parietal suture can no longer be distinguished—is long and bounded posteriorly by a narrow and well-defined " temporal fossa," which is continued downwards along the paroccipital process.

The *supra-occipital* is pierced by a small fontanelle, such as is usually met with in the Anatidæ.

The *postorbital* process differs conspicuously from that of the typical Duck, and resembles that of the Mergansers in that it is short and directed downwards. In the normal Ducks this process is of considerable length and directed downwards and forwards.

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The interorbital septum is largely fenestrated. The mes-ethmoid does not extend as far forwards as the free end of the premaxillary limb of the lachrymal. There is no ossified antorbital plate, and no nasal septum. The anterior nares are of considerable size—larger than in *Somateria*.

The hyoid bones differ but little from those of typical ducks. The basi-hyal is of great size, shows traces of its paired origin, and is pierced at the base by a large cordiform fenestra. The 1st and 2nd basi-branchials are fused.

The skull of *Biziura* may be distinguished from that of all other Anserine birds by the curiously truncated form of the upper jaw; the free lachrymal, which is further remarkable for the great length of the descending processes and the shortness of its horizontal limbs; the short blunt postorbital process; the peculiar shape of the grooves for lachrymal gland, which do not meet in the middle line, nor extend backward beyond the post-orbital processes; the great size of the anterior nares; and the perforate interorbital septum.

In the curiously forward tilted position of the quadrate, and the angulated quadrato-jugal, *Biziura* resembles *Somateria* and the Mergansers, but in *Biziura* this feature is most marked.

Although *Biziura* at the present day appears to derive much of its support from the sea, it would seem that it is essentially a freshwater species. And this may be inferred from the small size of the supra-orbital groove for the lachrymal glands, which, in *Somateria* and *Œdemia* for example, extend far backwards as shallow depressions over the roof of the skull, and in *Tachyeres* almost touch the lambdoidal ridge. In *Tachyeres* and *Somateria* this glandular area is increased by the development of the orbital processes of the lachrymal, which project outwards, upwards, and backwards after the fashion of a pair of horns. Deep supra-orbital depressions, more sharply defined, occur in the Sphenisci and the Colymbi, the Petrels and Gulls, and, less well defined, in the Plovers, which swim and dive only on relatively rare occasions. Thus there seem to be good grounds for associating the develop-ment of this groove with the necessity for a large supra-orbital gland in marine diving birds. This seems to be supported by the fact that in the Mergansers, which are freshwater diving ducks, this groove is wanting and the gland only feebly developed.

Thus we have a parallel case to the Grebes and Divers. The former are freshwater divers, and have much smaller supra-orbital glands than in the latter, which are marine. Both Grebes and Mergansers, however, are to be met with at sea, the latter commonly, but it would seem that this habitat is of recent date.

In *Tachyeres* and *Somateria* the fore part of the head lying between the orbit and the base of the beak has become enormously elongated, drawing out the nasal limb of the lachrymal to an extent elsewhere unknown among the Anseres. In *Biziura* this region is abnormally short, wherein it agrees with what obtains among the Mergansers. The lachrymal of *Biziura* again also closely resembles that of the Mergansers.

On the whole the skull of *Biziura* resembles that of *Erismatura* more closely than that of any other duck; but differs from this genus in that *Erismatura* possesses an ossified antorbital plate, and a large triangular lachrymal, an unfenestrated interorbital septum, a long postorbital process, and a long spatulate beak. Unfortunately I have no skeleton of any other member of this group of ducks wherewith to carry these comparisons further.

The Vertebral Column.

Only the thoracic, synsacral, and caudal vertebræ seem to require notice here.

In *Biziura* all the thoracic vertebræ bear long hypapophyses. From the 2nd to the 5th the free ends of the spines expand to form horizontal ⏊-shaped plates.

These hypapophyses have undoubtedly been developed to increase the power of diving; but whether they have been acquired as the direct result of a long-sustained stimulus through a long series of generations—that is to say, by the inheritance of acquired characters—or whether by the selection of favourable variations in this direction, I cannot pretend to say.

It is significant to note that these processes are wanting in the Geese. In non-diving ducks, e. g. *Anas*, only three are present, and these lack the ⏊-shaped process. The Sheldrakes agree with the diving Scaups, having four of these vertebræ with hypapophyses. In the Scoters and Eider-Ducks, which are sea-ducks and expert divers, there are 7 of these processes as in *Biziura*. They are longer and have larger ⏊-shaped plates than in *Anas*, *Fuligula*, or *Tadorna*. *Erismatura*, as we might expect,

most nearly resembles *Biziura* in this matter. It is a curious
fact, that in the Mergansers, where one would expect to find
these processes extremely well-developed, they are, on the con-
trary, smaller and fewer than in any other diving ducks—
numbering but 5, and having very small ⊥-shaped processes.
Taken in conjunction with the fact that these birds differ also
from the sea-ducks in the absence of supra-orbital depressions
for the supra-orbital gland, it would almost seem as though their
partially marine habitat had been adopted quite recently.

Outside the Anseres, hypapophyses occur in the Penguins,
Grebes, Divers, Cormorants, and Alcidæ, all types which dive
for their food.

In the Penguins the hypapophyses 1–3 have their free ends
expanded to form the horizontal plates described in *Biziura*;
behind these follow 4 simple processes. In the Divers these
expanded free ends occur on 1–2—where they are very large—
and 3, where they are small; behind these follow 4 simple
spines. In the Grebes—freshwater divers—spines 1–3 have
feeble lateral plates and the rest simple. The Alcidæ (Guille-
mots, Auks, &c.) have extremely well-developed hypapophyses.
Here 1–4 have very large lateral plates, 5–8 are simple. In the
Cormorants it is somewhat surprising to find all the hypapophyses
1–7 of the simple type—there are no lateral plates. In the
Gannet, Pelican, Frigate-birds, &c. these spines are altogether
wanting, and this because though they swim much, yet they
do not dive. Thus we have a parallel to the case of the Geese
and Swans among the Anseres.

The vertebral centra in these diving birds are much com-
pressed laterally.

The Shoulder-Girdle and Sternum.

There are no points calling for special comment in the
shoulder-girdle of *Biziura*. The sternum does not exactly
agree with that of any other duck with which I have compared
it. The spina externa and interna are wanting. The posterior
lateral processes are free, short, and curved, and project beyond
the level of the metasternal border. In that these processes are
free they resemble those of *Erismatura*, *Somateria*, and *Œdemia*,
Dendrocygna, and the Geese and Swans. That is to say, in this
character these birds represent a less specialized condition
than that which obtains in the Ducks generally, where the free

ends of the lateral processes meet the angles of the truncated metasternum to form fenestræ *. In the Sheldrakes and the Red-fronted Goose, for example, the union of these elements is nearly complete.

In *Clangula* the metasternum is of great width, converting the sternal notches into fenestræ by joining with the posterior lateral processes ; further, the metasternum is peculiar in that its cartilaginous free edge has become partly ossified. In *Harelda* this cartilaginous element is greatly increased, forming a large linguiform plate, and, at the same time, by increasing the width of the metasternum, it has, in very old examples, converted the sternal notches into fenestræ as in *Clangula*.

In *Biziura* the sternum is relatively longer than in other Ducks, and it also tends to taper anteriorly. The anterior lateral processes are obliquely truncated as in *Erismatura*. In *Erismatura* there is a broad, bifid *spina externa*, but in *Nomonyx* this process is remarkably well-developed, therein agreeing with the Geese. In *Tachyeres* it is moderately large. In all other ducks this process is either vestigial or wanting.

The keel of the sternum in *Biziura* shows evident signs of degeneration, being extremely low, and terminating some distance before reaching the end of the sternal plate. The accompanying illustration will show the relative proportions of the keel between *Biziura* and *Erismatura*. In the marked length of the sternal plate we have an evident adaptation to diving habits.

It is curious to note that the degeneration of the keel in *Biziura* is more marked than in *Tachyeres*, which is actually flightless.

The Mergansers only among the Ducks have the ventral border of the keel produced far forwards, in a fashion recalling that of the Cormorants and Gannets. In *Mergus serrator* this feature is especially well-marked. The precise significance of this is not obvious.

The Ribs.

The hindmost ribs of *Biziura* recall those of the Colymbi and Alcidæ, in that they are much elongated, running almost parallel with the pubis. Only the first five of the thoracic ribs appear

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* *Erismatura vittata* appears to form one of those puzzling exceptions which seem to be inseparable from every rule, inasmuch as the notches are in this bird not only converted into fenestræ, but the closing process has gone so far as to come near the obliteration of the fenestra of the left side altogether.

to bear uncinate processes. In *Fuligula*, as in *Anser*, there are six uncinate-bearing ribs, the first being that commonly regarded as the last cervical, since it does not become attached to the sternum. In *Erismatura* there are seven uncinates, the first attached as in *Biziura*.

There are altogether 10 thoracic ribs in *Biziura*, of which 8 are attached to the sternum, the 9th just fails to reach the sternal border, while the 10th is vestigial. *Erismatura* possesses 9 thoracic ribs, of which 8 are attached. Only in *Anser* and the Swans, it appears, is so high a number of ribs as 10 attained. In *Cygnus buccinator* there are 9 ribs attached to the sternum, while the 10th is of great length.

No less than four ribs are overlapped by the pre-ilia in *Biziura*, and the same is true of *Anser* and *Branta* among the Geese; but in no other Ducks are there more than three overlapped ribs, so far as I have been able to discover.

The great number of ribs in *Biziura* is to be taken as a primitive character, since in the more highly specialized ducks, as in *Querquedula* for example, there are only 8 pairs, of which but 6 pairs reach the sternum.

THE PELVIC GIRDLE.

The pelvic girdle of *Biziura* is remarkable for its extreme narrowness, which gives it an unusually elongated appearance. This narrowness is partly the result of a reduction of the width of the postacetabular ilium, and partly of the transverse processes of the synsacrum. The result of adaptation to diving habits, this girdle has come to bear a really striking resemblance to that of *Podiceps* or *Colymbus*, in which this narrowness has reached its maximum. As in these birds, so in *Biziura*, the preacetabular ilium has become shortened, while the postacetabular region has become lengthened.

Relatively longer than in any other Anatidæ, the proportions of the innominate bones are markedly different. Thus in *Biziura* the length of the preacetabular ilium from its anterior margin to the base of the antitrochanter is exactly $\frac{1}{3}$ of the whole pelvis. *Mergus* approaches nearest to these measurements, the length of the preacetabular ilium, taken as in *Biziura*, is $\frac{3}{8}$. *Œdemia*, *Somateria*, and *Erismatura* give a measurement of $\frac{3}{7}$.

This forward shifting of the acetabulum is to be taken as a sign of specialization—of adaptation to the requirements of

diving, since a precisely similar modification obtains in the Grebes and Divers.

The pelvis of *Mergus*, among the Ducks, approaches nearest, in its general conformation, to that of *Biziura*. In so far as the reduction in the width of the postacetabular ilium is concerned, indeed, the two genera are practically identical. In both, this portion of the innominate is represented only by a narrow blade of bone twisted so as to lie almost vertically. The peculiarly narrow pelvis of *Biziura* is brought about by the reduction of the transverse processes of the synsacral vertebræ. Between the pre-ilia, indeed, even the neural spines have become reduced (in thickness), so that innominates of this region meet in the middle line to form an almost knife-like edge. In the region between the antitrochanters the pelvis is normally at its broadest. In *Mergus* the innominates are separated one from another for half an inch by the transverse processes of the sacral and neighbouring vertebræ, but in *Biziura* they are divided only by a slightly swollen neural crest. As this is traced backwards the shelf formed by the transverse processes gradually appears, but at its widest the ilia are not separated by more than ·4 of an inch.

Since this extremely narrow type of pelvis occurs both in marine and freshwater species, it would seem either that Eider-Ducks and Scoters, now almost exclusively marine, have only recently become confined to this habitat ; or that for some unsuspected reason they have escaped the transforming effects of the environment, so obvious in such homoplasts as the Colymbi and Alcidæ, for example.

The ilio-ischiadic foramen is relatively larger in *Biziura* than in any other of the diving ducks. In the Fuligulinæ it is divided into two by a broad median bar.

The pubes of *Biziura* have very long free ends curving abruptly inwards towards the middle line, so as to very nearly touch one another. In *Mergus*, *Œdemia*, and *Somateria* the free ends of the pubes are yet longer, but are directed downwards and slightly backwards, curving inwards at the same time. The pectineal process is well-developed.

The Pectoral Limb.

In *Biziura* the humerus is slightly longer than the fore-arm, and in this it agrees with *Erismatura*, *Somateria*, *Œdemia*, *Mergus*, and *Fuligula*, for example. The manus and fore-arm

are subequal, and in this respect *Biziura* and *Erismatura* agree, and differ from all the species herein used for comparison, inasmuch as in these the manus is by far the largest segment of the wing.

Although *Biziura* is a larger and heavier bird than *Somateria*, the wing is altogether of a more slender character; and this is most evident in the manus. The metacarpals are fragile, Mc. II. having a diameter of a little less than $\frac{2}{12}$ in., while in *Somateria* the diameter in the same region is about $\frac{4}{12}$ in. Mc. III. is represented by a long and delicate bar, separated from Mc. II. only by a narrow chink; in *Somateria* Mc. II. is outwardly bowed and much stronger. The phalanges in *Biziura* are much reduced.

Although the wings of *Biziura* and *Erismatura* show the same general proportions in the matter of length, it by no means implies that *Erismatura* stands in such imminent danger of flightlessness as would seem to be threatening *Biziura,* inasmuch as it is a smaller and more active species.

It is interesting to remark that in so far as size is concerned there is little, at first, to indicate the degenerate condition of the wing in the flightless *Tachyeres.* Slightly longer in the humerus than *Somateria*, in the lengths of the fore-arm and manus *Tachyeres* and *Somateria* agree exactly. But the bones in *Tachyeres* are all much thicker than in *Somateria*. The decadent condition of this wing becomes apparent when we reflect that *Somateria* is at least one-third smaller than *Tachyeres*.

This bird, it is generally believed, loses its power of flight after the first moult. But it would seem that not even the young birds fly, since Mr. M. J. Nicoll, writing to the ' Ibis,' 1904, p. 49, remarks : " In most accounts of this bird it is stated that it rows itself along through the water with its little wings at an incredible rate. It certainly goes very fast, but practically it runs in the water flapping its wings clear of it ;" and continues : " The young travel through the water nearly as fast as the adults, in which the muscles of the legs are enormously developed." From this it would seem that the decay of the wing began by a reduction in the size of the remiges ; later the skeleton became affected. It is, however, a moot point as to whether the skeleton of the wing has, as yet, undergone any appreciable change, inasmuch as in the proportions of its several segments it preserves all the relations of a functional wing.

In so far as the length of the wing is concerned, it is hard to say whether it has really undergone reduction, or whether the disproportion between the size of the wing and of the body is not due to an increase in the latter, while the former has remained stationary. While, however, *Somateria* and *Tachyeres* agree so closely in the matter of the length of this limb, they differ conspicuously in that the several bones thereof in *Tachyeres* are much thicker and heavier, and this seems to show that a shortening process has begun. The evidence so far to hand seems to support one view almost as well as the other. Later I propose to enter with some detail into this question, when dealing with the wings of Struthious birds.

THE PELVIC LIMB.

The hind limb of *Biziura* presents some interesting evidences of adaptation in the direction of increased swimming powers. It is a noticeable fact, however, that the relative length of the several segments of the leg have remained practically unaltered; indeed there is a singular uniformity in this matter throughout the ducks generally: *Anas*, for example, on the one hand, the diving ducks on the other, presenting almost the same relative proportions—the femur being about $\frac{3}{5}$ the length of the tibio-tarsus.

Unless the present specimen be abnormal, the femur in *Biziura* is remarkable for its deep dorso-vertical curvature, and the exceptional development of the scars for the origin and insertion of the muscles. In the curvature of the shaft, *Biziura* is nearly approached by *Erismatura*.

The ecto- and entocnemial crests of the tibio-tarsus are well developed. In the form of the entocnemial crest *Biziura* is peculiar in that it is long and low. *Œdemia* approximates very closely to this type, but the crest is deeper. *Erismatura* is inter-mediate in this particular. In *Tachyeres* the crest is linguiform and of great size.

The tarso-metatarsus is flattened antero-posteriorly, grooved in front, and twisted on itself. The hypotarsus is complex. In its general form the tarso-metatarsus approaches very closely to that of *Tachyeres*, since in both these birds the shaft is unusually stout. In *Somateria*, for example, the shaft is relatively slender, tapering rapidly from the glenoid mesotarsal articular surface.

In the Mergansers it is also slender, and almost quadrangular in section.

The outer and middle toes are of equal length, as in *Tachyeres* and *Somateria*, for example.

In the form of its patella *Biziura* is unique among the Anseres. This sesamoid is of great size, pyramidal in shape, triangular at its base, and rising into a great crest whose anterior border looks inwards : further, as in the Cormorants, it is traversed by a tunnel for the ambiens. In no other duck is the patella completely ossified ; and only in *Tachyeres* is there any approach thereto in size, but in this genus it remains fibrous throughout life.

SUMMARY.

Unfortunately the Erismaturinæ are represented in the National Collection, in so far as skeletons are concerned, only by a single specimen each of *Erismatura jamaicensis* and *E. vittata* and a sternum of *Nomonyx*. This fact, and the still immature condition of the skull in the skeleton of *Biziura* now under consideration, makes any generalization as to the affinities of *Biziura*, as indicated by osteological characters, a matter of difficulty. The genera *Erismatura*, *Thalassiornis*, *Nomonyx*, and *Biziura* have been placed together by Count Salvadori (Cat. Birds Brit. Mus. vol. xxvii.) in a separate subfamily—the Erismaturinæ. This he places between the Fuligulinæ on the one hand, and the Merganettinæ and Merginæ on the other.

The osteological characters of these groups certainly do not seem to bear out this classification.

The Erismaturinæ should be merged in the Fuligulinæ, since they are undoubtedly closely allied to the genera *Aythya* and *Fuligula*, and more distantly to *Clangula*. On the other hand, the genera *Tachyeres*, *Harelda*, *Histrionicus*, *Œdemia*, *Heniconetta*, *Somateria*, and *Erionetta* might well be placed together in a separate subfamily—the Somateriinæ. They have much in common, and are quite distinct from the Fuligulinæ. It is open to question whether the Merganettinæ should be separated from the Merginæ.

Biziura is primitive in some respects, in the skull for example, and highly specialized in others, as in the form of the pelvis and of the hypapophyses of the vertebræ.

The remarkable gular pouch of this bird was figured and described by Forbes (P. Z. S. 1882).

SKULL, PELVIS, AND KNEE-JOINT OF THE MUSK-DUCK.
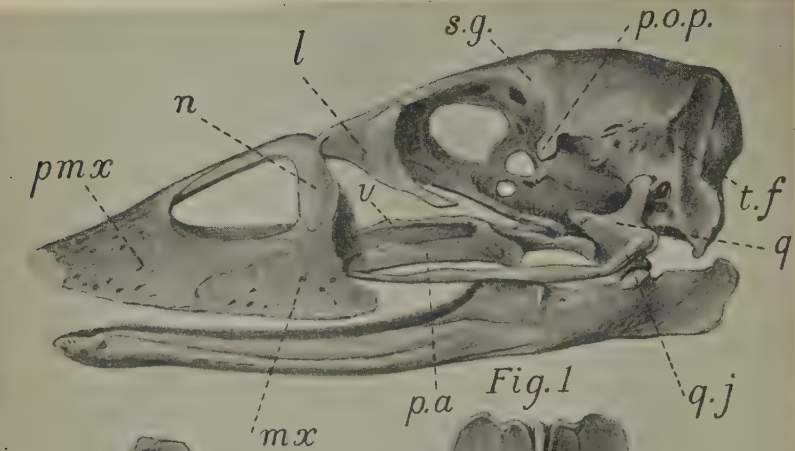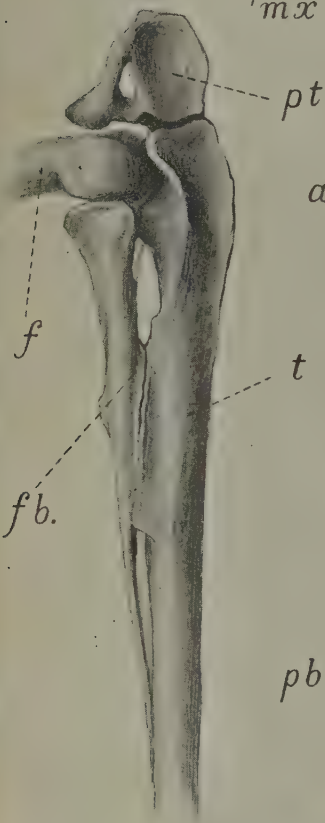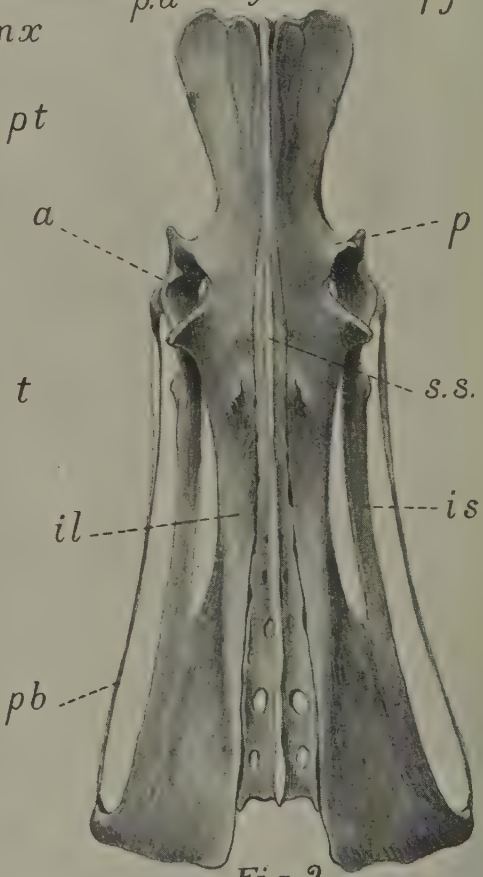
EXPLANATION OF PLATE **39.**

Fig. 1. Skull of *Biziura lobata*, side view.

     l.=lachrymal. *mx.*=maxilla. *n.*=nasal. *pa.*=palatine. *p.o.p.*= postorbital process. *t.f.*=temporal fossa. *q.*=quadrate. *v.*=vomer.

Fig. 2. Pelvis of *Biziura lobata*, dorsal aspect.

     a.=acetabulum. *il.*=ilium. *is.*=ischium. *p.*=pre-acetabular ilium. *pb.*=pubis. *s.s.*=synsacral crest.

Fig. 3. Portion of right leg of *Biziura lobata*, outer aspect.

     f.=femur. *fb.*=fibula. *pt.*=patella. *t.*=tibia.

On the Membranous Labyrinths of certain Sharks.
By CHARLES STEWART, F.R.S., F.L.S.

[Read 16th November, 1905.]

(PLATE **40.**)

THE admirable monograph on the organs of hearing of the vertebrata by Prof. Retzius * leaves little or nothing that one would wish to add to the account of the forms therein treated ; but having had the opportunity of examining some not dealt with in that work, it seems desirable to give some record of their structure.

One cannot but recognize that features apparently most trivial may prove useful in helping to show the real affinities of an organism, and occasionally the solution of the more difficult question of the function of a structure may be suggested, when such a structure is found to be possessed by forms dwelling in a like environment that by other features have had their affinities differently interpreted.

NOTIDANUS GRISEUS. Fam. Notidanidæ.

In this Shark the utricle presents the ordinary elasmobranch features as figured by Retzius and others, being divided into two portions not directly communicating with one another and with their walls completely separate. In spite of the fact that Retzius reserves the name utricle for the anterior of these, and calls the other posterior canal, I propose speaking of them here as utriculus anterior and utriculus posterior ; for a comparison with the utricle of *e. g.* Teleostea leaves no doubt that they are portions of that chamber (*l. c.* p. 218).

The anterior utricle has no direct opening into the saccule, but communicates with it indirectly through the recessus utriculi.

* 'Das Gehörorgan der Wirbelthiere,' Bd. i. (1881).

A large aperture (ductus utriculi) in the floor of the utricle opens into the recessus, and from the postero-superior parts of the recessus a tube-like passage (canalis recessu saccularis) leads into the saccule.

As the skin was required for other purposes, the nature of the superficial portion of the ductus endolymphaticus and its opening could not be determined.

LÆMARGUS BOREALIS.   Fam. Spinacidæ.

In this species the labyrinth has a considerable resemblance to that of *Notidanus.*

The ductus endolymphaticus, after passing through the cartilaginous roof of the skull, takes the usual forward course, but more directly upwards than in most cases; at the extremity this portion it ascends nearly vertically to its cutaneous opening. The recessu-sacculine and posterior utriculo-sacculine canal much wider than in *Notidanus.* The sacculus is small, with lagena cochliæ as a large depression of its postero-inferior a The dorsal extremities of both portions of the utricle are dilated than in *Notidanus.*

LAMNA CORNUBICA.   Fam. Lamnidæ.

On examining this form, one is at once struck by the apparent fusion of portions of the two divisions of the utricle, forming a structure that has a close superficial resemblance to the sinus superioris utriculi of the Teleosts; their cavities, however, remain distinct.

In front and parallel to this may be seen the ductus endolymphaticus passing upwards to penetrate the skull; it then passes forwards in close contact with the skull for about 18 mm., and bends for a short distance backwards before ascending nearly vertically to its external opening. The sacculus is small and cylindrical, terminating in a lagena cochliæ wider than itself. The recessus utriculi opens into the utricle above and the sacculus behind by a common orifice. At the same point the ductus endolymphaticus arises. Two small ramuli neglecti pass to the macula neglecta on the outer side of the posterior utriculo-sacculine canal.

ALOPECIAS VULPES.   Fam. Lamnidæ.

In this Shark the ductus endolymphaticus lies in a similar position to that in *Lamna,* well anterior to the blended portions

of the utricles, which in this case still more closely resemble the Teleostean sinus superioris utriculi.   The extra-cranial part of the ductus endolymphaticus appears to make the usual forward bend in close contact with the skull ; it then seems to pass backwards for a short distance, is then directed forward again for a short distance in front of the first bend, passing again backwards, and finally ascending to its external opening. The sacculus and lagena resemble those of *Notidanus* and *Læmargus.*

CARCHARIAS LAMIA.   Fam. Carchariidæ.

The very large size of the sacculus in this Shark results in the ductus endolymphaticus immediately after its origin passing through the skull ; it there makes the usual bends, forwards and backwards, and finally upwards to its external opening.   The recessus utriculi has similar communications with the utricle and sacculus as in *Notidanus* and *Læmargus.*   The canalis utriculo-saccularis posterior is remarkably dilated into a rounded chamber shortly before its termination in the sacculus, and blending with it is a like dilatation of the utriculus.   The ramulus neglectus is, as usual, given off by the nerve that supplies the ampulla of the posterior canal.   It is of unusually large size ; it sends a small twig to the dilatation on the utricle, but by far the larger portion is distributed to the macula on the dilatation of the posterior utriculo-sacculine canal.

EXPLANATION OF PLATE 40.

The right membranous labyrinths of five genera of Sharks, viewed from the mesial side ; all except fig. 3 are of natural size, fig. 3 × 2.

a. Ampullæ.	*d.r.u.* Ductus recessu utriculi.
a.d.e.e. Apertura ductus endolymphatici externa.	*l.* Lagena cochliæ.
	r.n. Ramulus neglectus.
c.a. Canalis anterior.	*r.u.* Recessus utriculi.
c.e. Canalis externus.	*s.* Sacculus.
c.p. Canalis posterior.	*s.e.* Saccus endolymphaticus.
d.e. Ductus endolymphaticus.	*u.a.* Utriculus anterior.
d.u.s.p. Ductus utriculo-saccularis posterior.	*u.p.* Utriculus posterior.

Fig. 1. *Notidanus griseus.*
2. *Læmargus borealis.*
3. *Lamna cornubica.*
4. *Alopecias vulpes.*
5. *Carcharias lamia.*

Some Notes on the Life-History of *Margaritifera panasesæ*.
By Arthur W. Allen, B.A. (Camb.).   (Communicated
by Rev. T. R. R. Stebbing, F.R.S., Sec.L.S.)

[Read 18th January, 1906.]

Margaritifera panasesæ is a small Mother-of-Pearl Oyster,
of no commercial value or use. It is found in various parts of
the Pacific, more especially in New Guinea waters. The species
was identified in 1901 as Gould's *Avicula maculata* by Dr. H. L.
Jameson, and appears in his classification of Mother-of-Pearl
Oysters under the above name (see Proceedings Zool. Soc. Lond.,
April 26, 1901).

In appearance the shell is not unlike several species of
Lingahs, although smaller and less convex. Its antero-posterior
measurement seldom exceeds $1\frac{1}{2}$ inches, the largest specimen I
have being $2\frac{1}{2}$ inches. In markings and colour there is much
variation. The ground-colour may be either white, black, dark
green, or purple. The shell may be either uniformly white or
uniformly dark. When the ground-colour is white, markings
generally occur as black, purple, or dark green irregularly placed
blotches or regular radii. The nacre, which is generally tinged
yellow, is transparent, except in old shells, and possesses a
reddish-green sheen.

My observations were made consequent on the discovery of
an enormous natural deposition of the spat of this species in a
secondary lagoon of several acres in extent, which encloses one
of the central islands (Itamarina) of the Conflict Group Atoll,
British New Guinea. During the months of February and
March I have estimated, on several occasions, that the deposit
amounted to fifty or so young shells per square foot of suitable
ground. There was very little evidence of such a deposit a few
days after it had been noted, and by August there was little or
no trace of any shells having survived. What Huxley said of
the precariousness of the early existence of the edible oyster is
equally applicable to this species:—" The minute larvæ are
probably swallowed by everything which has a mouth large
enough to admit them ; and as soon as the young oysters have
become sedentary, they are eaten by everything which has jaws
strong enough to crush them."

Many shells of this species seem to overestimate the importance

of a protected position, and only survive a few months, the secluded spots they have anchored in proving too small for the growing shells. A large number are smothered in silt or sea-weed ; and amongst the enemies of those that manage to secure themselves to a support may be mentioned the numerous species of fish, crabs, starfishes, &c. A peculiarly insidious enemy is found in the person of a small whelk, which, during the first few months of growth, pierces a neat hole in the thin shell, producing, apparently, a paralytic effect on the adductor muscle, with the result that the bivalve loses the power of closing its shell against the unwelcome visitors. Quantities of young dead pearl-shell are washed up on to the beaches with every returning tide, . and on a large proportion of these is found this small per-foration, and, curiously enough, in the majority of cases this is situate in the neighbourhood of the attachment of the adductor muscle.

The species is diœcious, and the embryo is formed by the union of the sexual elements outside the shell. After a free-swimming stage of probably a few days' duration, a pair of shells is formed ; and the embryo, as a result of its increased weight, sinks to the bottom and is washed into, and lodges in, the crevices between layers of seaweed or at the junction of the branches of dead coral and other places. At this stage the shells measure 1 mm. to $1\frac{1}{2}$ mm. in diameter, and in appearance are either pure white or else have a white ground with circumferential dark green or black blotches, forming a band either wholly or partly around the margin.

In many cases, where the situation is an exposed one, the young shell, after deposition, makes a tour of the neigh-bourhood in search of a cranny where it can hide itself from the detection of its enemies. For the purposes of locomotion, a modified foot is cautiously protruded from the region of the byssal cleft. It has the appearance of a muscular thread, and its maximum length is about equal to that of the hinge-margin. This organ, after describing circulatory movements and testing the ground in every direction, attaches its extremity in the direction decided on, and, by the contraction of its substance, draws the oyster after it, the latter resting with its flatter side (*i. e.* the right valve) below. Progress is necessarily slow ; nevertheless, I have known spat under observation travel a foot or so during a few hours previous to anchorage.

At this stage, and in the majority of positions, the young shell runs the risk of being washed away, and its existence ended by being smothered in silt. To guard against such a contingency happening whilst the bivalve is unattached, a minute thread, similar in appearance to a strand from a spider's web, is during its progress paid out. This thread is strong enough to sustain the weight of the oyster, and by its aid it is enabled, if necessary, to regain its lost footing. I did not for some time suspect the existence of this thread, as it is invisible except under the closest observation. However, whilst I was noticing some movements of spat placed on a suspended slab of cement in a small aquarium, I found that the spat travelled to the edge of the slab and, in some cases, succeeded in reaching and anchoring itself on the under surface (away from the light) without mishap. Others, however, were not so fortunate, and on reaching the edge toppled over, but, to my surprise, did not fall to the bottom of the tank, but remained a fraction of an inch or so below the slab, suspended, as I then discovered, by means of the minute thread referred to above. To regain its position on the slab was then a comparatively easy matter for the oyster. I think it probable that the presence of these minute threads may explain the fact that these shells are so often found grouped together and even anchored on one another.

As soon as a suitable locality has been found, the shell secures itself by means of its byssus, an attachment which at first consists of a single strand, adhesion being effected by means of a disc-like expansion of its extremity. Other strands are fixed in all directions as the shell grows older, and the resultant bundle is the means of the oyster maintaining an upright and rigid position. The strands are so firmly attached to the anchorage that, if the oyster is forcibly torn away, the fracture occurs at the junction of the byssus and the oyster. Judging from the numbers of bundles observable on dead coral &c., it is probable that such a thing is of frequent occurrence under natural conditions. A new byssus is, however, always formed, the time taken for preliminary re-attachment being only an hour or so. Power of independent movement is, however, confined to shells of six months of age and under; and doubtless the possibility or the necessity of locomotion grows less and less as the shell grows older and its position more secure. This fact would be sufficient to account for the atrophy of the foot during
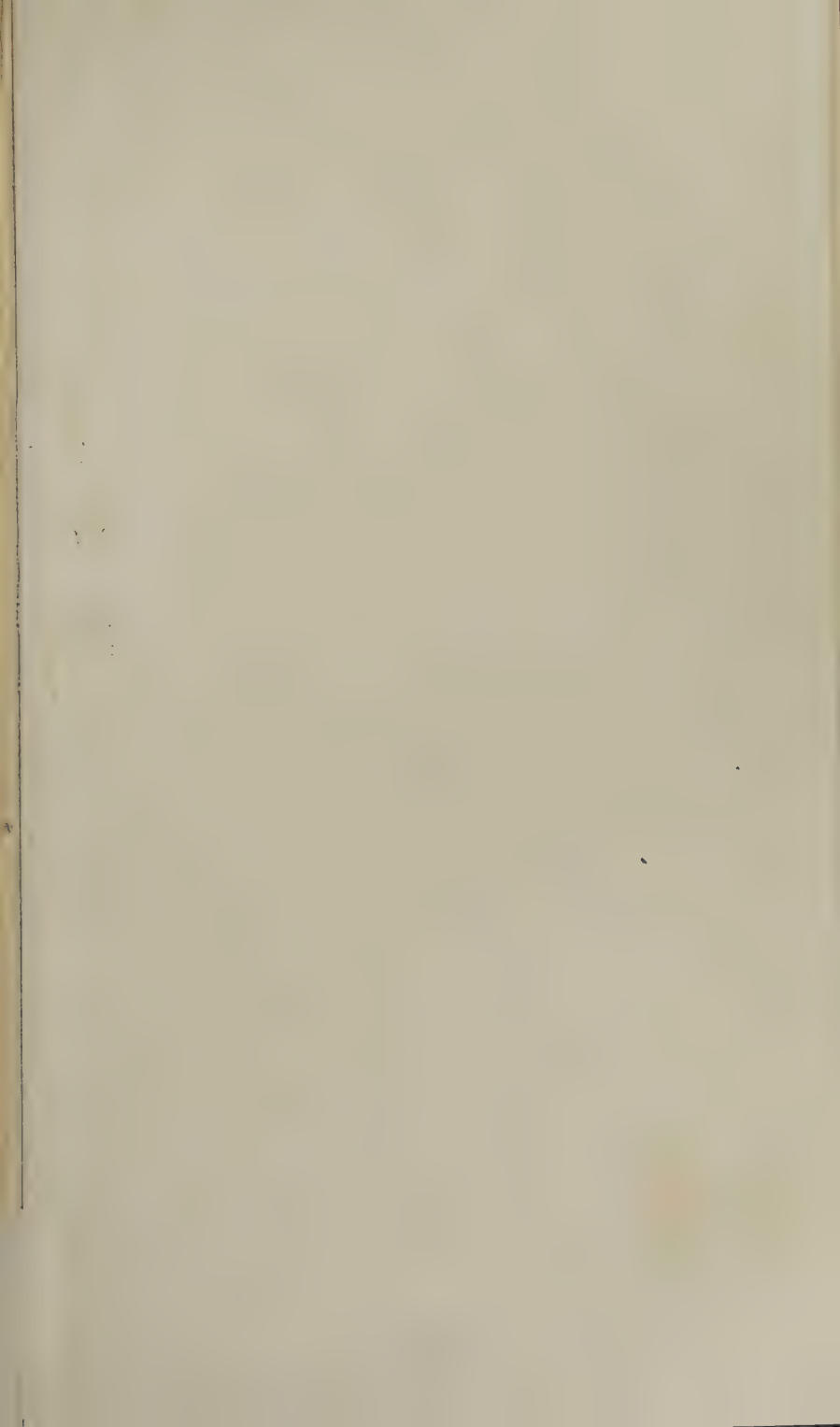
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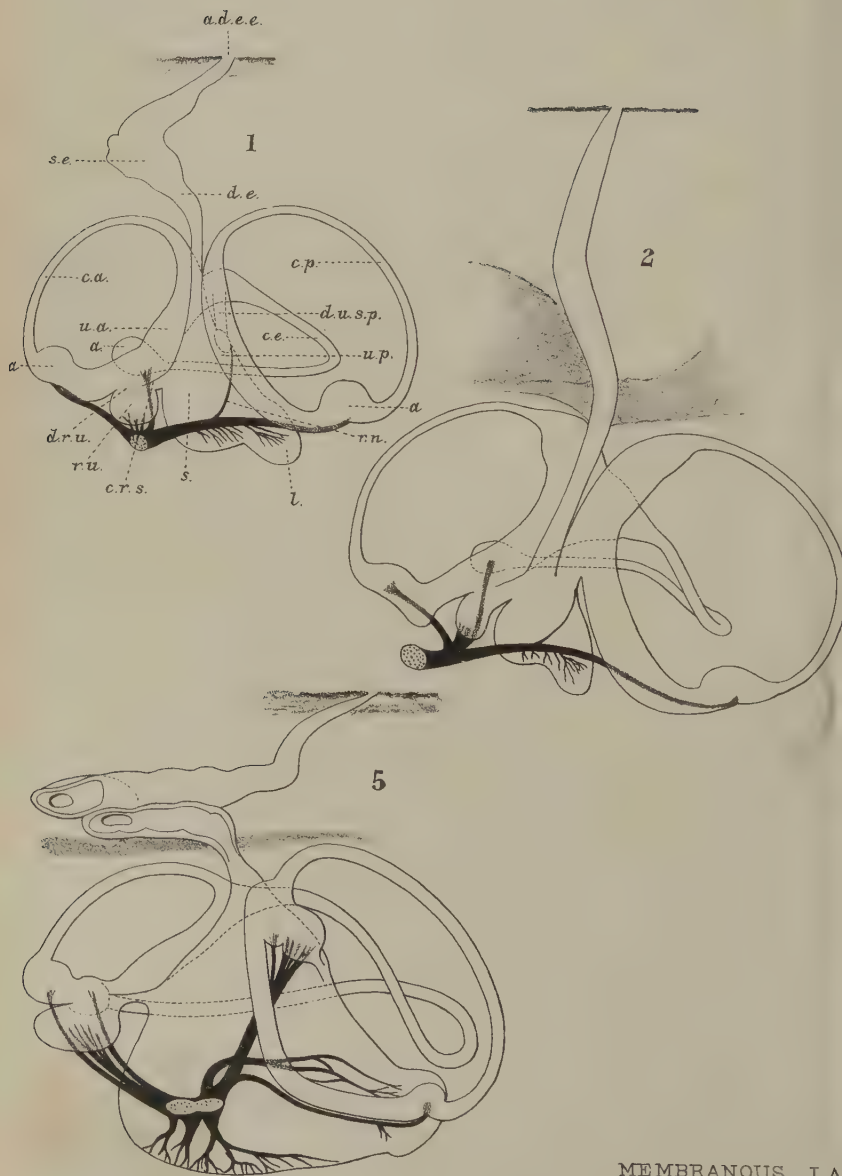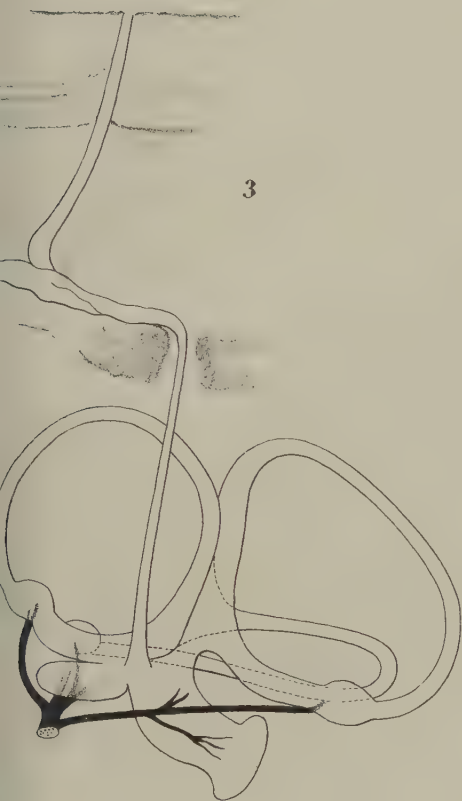
NTHS OF SHARKS.

the latter part of the existence of this bivalve. On the other hand, the formation of new byssi is possible, and, if occasion demands it, always occurs in shells of almost any age.

Degeneration consequent on a more sessile existence is observable, in this species, in the atrophy of the modified foot during the latter part of the bivalve's existence. The presence of rudimentary hinge-teeth in this species is also worthy of notice.

I have been unable to observe any indications of independent movement in the spat, or young shell, of the New Guinea variety of the black-edged Mother-of-Pearl Oyster (*Margaritifera margaritifera*). As in *M. panasesæ*, its byssus is permanent and persists throughout life, being instrumental in keeping the oyster in an upright position. In the event of accident a new byssus is formed (almost at any age, as in *M. panasesæ*), provided that suitable anchoring material exists within reach. This species possesses no trace of hinge-teeth.

In the white- or golden-lipped Mother-of-Pearl Oyster (*Margaritifera maxima*), of commercial importance, no movement is reported as having been observed in the young shell or spat. A byssus is formed, but it is not a permanent one, and does not persist beyond the ninth month or so. After that age, and for its stability, the shell relies on its weight and lies, unattached in any way, on the bottom. This species also possesses no traces of hinge-teeth.

With these three types it is possible to form an interesting series illustrative of the modifications which have taken place within the subgenus *Margaritifera*. *M. panasesæ*, with its rudimentary hinge-teeth, permanent and renewable byssus, whose formation is preceded by locomotion by means of a modified foot, may be taken as a type possessing the most primitive characteristics. *M. margaritifera*, showing absence of hinge-teeth and foot, but presence of permanent and renewable byssus, may be taken as a more advanced type. *M. maxima*, with absence of hinge-teeth and foot and with only a temporary byssus, may be taken as a type representing the highest development among the Mother-of-Pearl Oysters. Further investigations in connection with intermediate forms would no doubt make the series more complete.

Perth, W.A., Aug. 12, 1905.

On the Organ of Jacobson in *Sphenodon*. By R. Broom, M.D., D.Sc., C.M.Z.S., Victoria College, Stellenbosch. (Communicated by Prof. A. Dendy, D.Sc., F.L.S.)

[Read 21st December, 1905.]

(Plates **41** & **42**.)

Though something is known of the Organ of Jacobson in Lizards and Snakes, principally through the researches of Kitchen Parker (**1**), Born (**2**), and Seydel (**3**), scarcely anything has been published, so far as I am aware, concerning the organ in *Sphenodon*. Osawa (**4**) figures a transverse section showing the relations of the organ in the adult animal, and the mode of its opening into the choane, and he correctly states:—" Eine papillenartige knorpelige Einragung in das Organ wie bei der *Lacerta* kommt bei der *Hatteria* nicht vor.'' The bone which lies above the organ he incorrectly calls the " turbinale." This bone has since been shown by Howes and Swinnerton (**5**) to be the " septo-maxillary." In their paper on the development of the skeleton in *Sphenodon* they figure a section through Jacobson's organ showing the relations of the organ to the cartilages and bones, and state that whereas in *Sphenodon* " Jacobson's organ is completely roofed in cartilage, in the lizard, according to Parker, the septo-maxillary fulfils that function." Seydel (**3**), in his recent work on the organ of Jacobson in *Echidna*, refers to the condition in *Sphenodon*, and though he has evidently only superficially examined the organ, he has made the following highly important observations:—" Das Jacobson'sche Organ von *Hatteria* ist schlauchförmig und ist dem unteren Rande des Septums eingelagert. Seine Oeffnung liegt in der Nähe des vorderen Randes der Apertura interna; nach hinten endet der Schlauch blind. Das Organ erinnert also in Form und Lage an das der Mammalier; ob sich die Aehnlichkeit auch auf den inneren Bau erstreckt, weiss ich nicht. Jedenfalls ist die Thatsache bedeutungsvoll, dass bei einem recenten Reptil bei verhältnissmässig primitivem Zustande des Gaumens ein den Mammaliern ähnliches Jacobson'sches Organ besteht."

Through the kindness of my friend Prof. Dendy, who has very generously allowed me to freely examine his beautiful sections of *Sphenodon* embryos, I am fortunately in a position to give a

detailed account of the relations of the organ, and to confirm
Seydel's opinion as to its mammalian affinities. The sections
which most satisfactorily show the relations of the organ are a
series of transverse sections of the head of an embryo of Dendy's
stage R. At this stage the bones of the head are well ossified,
and the organs in young animals have their relations in a more
satisfactory condition for enabling comparisons to be made than
at later stages, when the primitive structure becomes frequently
somewhat obscured by specialization.

In a transverse section through the premaxillaries, the bones
are seen to be separated by a feebly developed portion of the
internasal cartilaginous septum. A similar condition is met
with in *Echidna*, but is not present either in the lizard, snake,
or tortoise.

Immediately behind this plane, the nasal septum is found to
be greatly expanded in its lower half as seen in fig. 1 (Pl. **41**).
It is continued externally into the delicate little cartilage that
supports the external nasal opening.

A short distance behind the plane illustrated by fig. **1**, the
lower part of the median cartilage is found to have four
openings—two large ones above for the accommodation of the
anterior parts of Jacobson's organ, and two smaller ones for
the anterior ends of the prevomers. Figs. 2 & 3 illustrate
sections in this region, and fig. 3 shows the lower part of the
cartilage forming a cartilaginous support for the papilla. The
presence of a papillary cartilage is unknown in Lizards or Snakes,
nor has it, so far as I am aware, been found in Chelonians or
Birds, but it is met with in the Crocodile. Among Mammals a
papillary cartilage has been shown by Wilson to be present in
the fœtal *Echidna*; and I have shown that a well-developed
cartilage is present in the majority of Marsupials, and among
higher forms in *Macroscelides* and *Miniopterus*.

In figs. 2 & 3 is seen the moderately well-developed septo-
maxillary bone. It forms the floor of the anterior part of the
nasal cavity, and to some extent protects the roof of Jacobson's
organ. In its relations it is seen to be strikingly dissimilar to
the septo-maxillary of either the lizard or the snake. In the
Squamata the organ of Jacobson is never roofed by cartilage as
in *Sphenodon*, and the septo-maxillary bone is highly developed
to protect the very large organ. The bone is firmly attached to
the nasal septum and usually surrounds the upper part of the

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organ, but never shows on the outer surface of the skull as in *Sphenodon*. In snakes the septo-maxillary is more largely developed than in lizards, and to a considerable extent supports the nasal septum beyond the limits of the organ of Jacobson.

A septo-maxillary bone has not hitherto been described as such in any mammal, but it appears to occur in the immediate ancestors of the Mammals, the Cynodonts, and is known to be present in the more primitive Therocephalians and Pelycosaurians. No trace of the bone has been found, however, in any Anomodont. In 1896 I discovered a nasal-floor bone in the Armadillo (*Dasypus villosus*), but did not at the time recognize its true significance. Fig. 9 represents a section through the bone; and if this be compared with figs. 2 & 3, it will be seen that there is considerable reason for regarding the " nasal-floor bone " of the Armadillo as homologous with the septo-maxillary of *Sphenodon*. The fact that the septo-maxillary is seen from the *Sphenodon* condition to be primarily a nasal-floor bone, and that the bone occurs in the mammalian ancestors, renders it exceedingly probable that the bone in *Dasypus* is a true septo-maxillary.

The organ of Jacobson, as illustrated in figs. 3, 4, 5, & 6, is seen to be relatively much less developed than in lizards and snakes, and to differ very much from the type found in the Squamata. It is a flattened lens-shaped organ which lies near the base of the nasal septum, between the prevomer and the nasal cavity. The anterior part of the organ, as seen in figs. 3 & 4, is supported below by the paraseptal cartilage, and above by a special roofing-cartilage. The plane of the organ looks upwards and slightly outwards. At a point near the middle of the outer side, the organ opens into the anterior end of the lower part of the nasal cavity, as seen in figs. 4 & 5. The lachrymal duct opens into the same part of the nasal cavity from the outer side. On passing farther backwards the organ is seen to be rather narrower than in front (see fig. 6). It ends quite abruptly and not, as is the rule in Mammals, by becoming a gland-duct.

The differences between the organ in *Sphenodon* and that in the typical representatives of the Squamata are much greater than might have been expected, considering the many lizard-like characters of *Sphenodon*. In the Lacertilia and Ophidia the organs are formed on a common type, and the differences, either

in structure or relationships, are comparatively slight. The organ is usually of large size, and has a well-developed turbinal process passing into it from its anterior and under side, and it is roofed by the large septo-maxillary bone. It usually opens more or less directly into the mouth, and it is only indirectly connected with the nasal cavity. In the Geckonidæ, which are probably the most primitive of living lizards, the organ opens with the lachrymal duct into a cavity which is connected with the nasal chamber, and in this group the septo-maxillary, though it forms the roof of the organ and articulates with the nasal septum, is considerably smaller than in the typical lizards. The Gecko thus shows a nearer affinity with *Sphenodon* than do the other lizards, and helps us to understand how the lizard type of organ may have developed from something like the *Sphenodon* type.

In the way in which the organ opens into the anterior part of the lower portion of the nasal cavity, the resemblance is much closer to the mammalian condition than to the lacertilian. In the mammal the resemblance is slightly obscured by the formation of the secondary palate by which the anterior part of the nasal cavity becomes the naso-palatine canal. In the mamma. the organ of Jacobson normally opens into the naso-palatine canal. This condition is found in the Monotremes, all Marsupials (except *Æpyprymnus* and *Notoryctes*), Ungulates, Carnivores, Insectivores, Bats, and Lemurs. It does not occur, however, in Rodents, *Dasypus*, or Man. The roofing of the organ by cartilage, though exceptional in Mammals, is by no means uncommon. It is met with in the Monotremes, a few Marsupials, and a number of Eutherians. In Mammals the organ only very exceptionally extends in front of the opening. In *Ornithorhynchus*, however, about as much of the organ lies in front of the duct as behind it, and the way in which the anterior part of the organ excavates the lateral cartilage is not unlike the condition seen in *Sphenodon*; and in *Ornithorhynchus* the cartilage is supported by the prevomer or " dumbbell bone," just as in *Sphenodon* it is supported by the bone usually, but I believe erroneously, called the " vomer." In no higher mammal does the organ extend much in front of the duct, but it does to a slight extent in *Perameles* and *Macroscelides*. A striking difference between the organ in *Ornithorhynchus* and *Sphenodon* is that in the former there is a well-developed turbinal passing

into the organ from the outer side. It also occurs in *Echidna*
but no higher mammal retains it. The appearance of the
cartilages in the Marsupials and Edentata, however, suggests
the belief that the higher forms are descended from animals
which had a turbinal in the organ. The relations of the
posterior part of the organ to the septum in *Sphenodon* are
typically mammalian.

With regard to the structure of the organ, so far as can be
made out from the sections of the embryos I have examined,
the affinities are much more with the Squamata than with the
Mammalia. The lower wall of the organ is composed of two or
three layers of rounded epithelial cells, apparently without
cilia: the upper and inner wall is formed of closely-packed
bunches of neuro-epithelium, as in the Squamata. In Mammals
the sensory epithelium is usually confined to the inner and lower
wall of the organ, but in the Monotremes it covers also the
upper wall of the organ.

The study of the organ of Jacobson and its relations helps
considerably towards the solution of the problem of the affinities
of *Sphenodon*. By Huxley, Osawa, and others, *Sphenodon* has
been held to be a true lizard. By Gadow and many others it
has been looked upon as an extremely primitive reptile not very
far removed from the Batrachians, and belonging to an order
from which almost all other reptiles have descended. It will
probably only be possible to definitely settle the position of
Sphenodon when palæontology has advanced much further than
at present, but it seems to me that enough can be said on each
side of the question to demand for the opposing views most
careful consideration. In many respects *Sphenodon* bears a
closer resemblance to the lizards than to other reptiles, but the
characters which they have in common are probably primitive
and shared by most of the early lizard-like forms. It seems
impossible that lizards with a distinct prosquamosal can have
descended from a *Sphenodon*-like form in which that bone is
lost; but lizards and *Sphenodon* may both have had a common
ancestor in Permian times which had a distinct prosquamosal
and a fully-roofed temporal region. Such an ancestor would
probably not be far removed from the Cotylosaurians, one of
which was the remote mammalian ancestor. *Sphenodon*, though
it has advanced far from the Cotylosaurian state, still retains a
number of the primitive characters, and the organ of Jacobson

is probably still of the same type as that possessed by the Cotylosaurians. In the Squamata the organ has become greatly developed and specialized, and more or less completely separated off from the nose.

The condition of Jacobson's organ in *Sphenodon* is of further interest in that it affords additional evidence, if such be any longer required, of the Reptilian affinities of the Mammalia. The palæontological evidence that Mammals are descended from a primitive but true reptile seems to be pretty conclusive; but, owing to most living reptiles having been much specialized, the relations of the mammal to the reptile are not so striking when one only studies the ordinary living types. In *Sphenodon* we have a reptile nearer to the primitive type than any other at present alive, and it is thus particularly interesting to find in it a type of Jacobson's organ so near to that of the mammal. In the mammal, possibly as the result of the large development of the incisor teeth, the organ has been forced to lie along the base of the nasal septum, and while degenerating as a sense-organ it has been retained largely as an excretory duct for the nasal glands.

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EXPLANATION OF THE PLATES.

C.e.n., cartilage of the external nares; *e.n.*, external nares; *J.O.*, Jacobson's organ; *l.d.*, lachrymal duct; *l.J.c.*, lower part of Jacobson's cartilage; *Mx.* maxilla; *Na.*, nasal; *n.c.*, nasal cartilage; *n.f.c.*, nasal-floor cartilage *n.s.*, nasal septum; *Pmx.*, premaxilla; *p.s.c.*, paraseptal cartilage; *P.Vo.*, prevomer; *S.Mx.*, septo-maxilla; *u.J.c.*, upper part of Jacobson's cartilage.

PLATE 41.

Fig. 1. Transverse section of nose of embryo *Sphenodon punctatus*, Stage R, showing the broad expansion of the lower part of the nasal septum immediately behind the premaxillaries. The section is through the anterior nares, and a portion of the supporting cartilage is seen above and below.

2. Transverse section a short distance behind fig. 1. The lower part of the septal cartilage shows four excavations. The upper two are for Jacobson's organ, the lower for the prevomers. The section shows the anterior part of the septo-maxillary.

3. Transverse section a little behind fig. 2. The anterior part of Jacobson's organ is seen, also the prevomers. The lower part of the septal cartilage is now seen forming a papillary cartilage (*p.c.*). The septo-maxillary is of large size, and forms part of the external wall of the skull.

Fig. 4, fig. 5, and fig. 6 are almost consecutive sections a little behind fig. 3. Fig. 4 shows a section of the organ where it is opening into the anterior and inferior corner of the nasal cavity in common with the lachrymal duct. The organ is roofed above and below by cartilage.

PLATE 42.

Fig. 5 shows the organ just behind its opening into the anterior part of the nasal cavity; the cartilage of the organ shows an upper and a lower part, the lower being manifestly the paraseptal cartilage. The lower part of the nasal cartilage is separated as a nasal-floor cartilage, almost exactly as is seen in most mammals. Fig. 6 is a section which in almost every respect is typically mammalian. With the exception of the fact that the mode of opening of the lachrymal duct is different, the section might pass for a section through the snout of a marsupial. In the marsupial, as in most mammals, Jacobson's cartilage is supported by the palatine process of the premaxilla: here the supporting bone is the prevomer.

Fig. 7. Transverse section a considerable distance behind fig. 6. The paraseptal cartilage is small and the prevomer large. The lachrymal duct is seen below the maxilla and the prefrontal.

8. Transverse section of snout of *Dasypus villosus*. Below the base of the true nasal septum are seen the anterior portions of the cartilages which become Jacobson's cartilages. Along the inner part of the nasal floor is seen the well-developed bone which is believed to be the septo-maxillary (*S.Mx.*). A little farther back it lies inside of the premaxillary, and has no connection with any other bone.

Broom.

Journ. Linn. Soc. Zool. Vol. XXIX. Pl. 41.
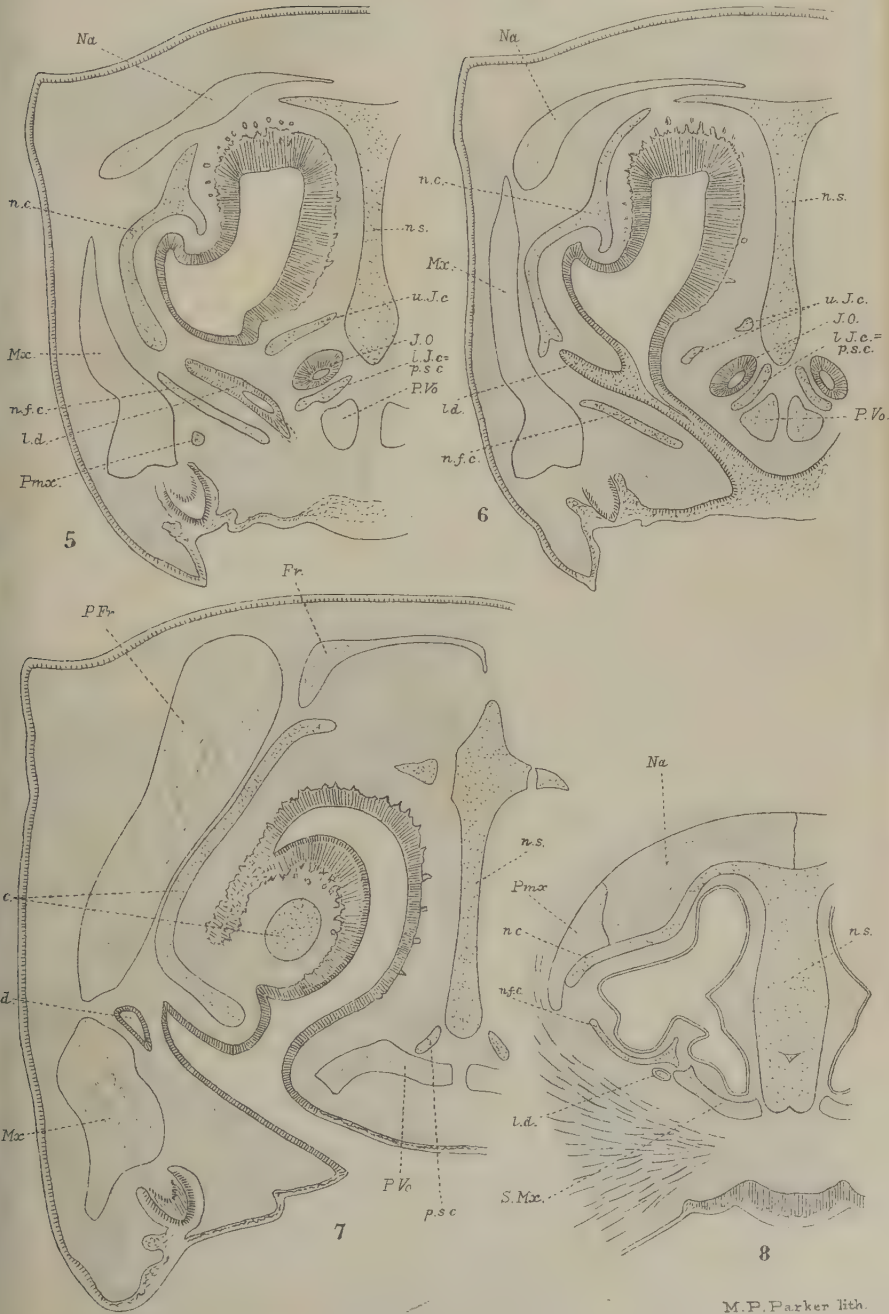
JACOBSON'S ORGAN IN SPHENODON.

R. Broom del.

JACOBSON'S ORGAN IN SPHENODON.

The Structure of *Isis hippuris*, Linnæus. By Jas. J. Simpson,
  M.A., Natural History Department, University of Aberdeen.
  (Communicated by Prof. W. A. Herdman, F.R.S., Pres.L.S.)

(Plate **43**.)

The genus *Isis* was established by Linnæus in 1737 in his
' Hortus Cliffortianus,' p. 479, but he did not then include under
the generic appellation the species to which it was afterwards
applied. These he referred to the genus *Sertularia*. In his
' Systema Naturæ,' ed. x. 1758, p. 1287, Linnæus rearranged
his species, and placed in the genus *Isis* not only the species
referred to, but also all the Isidinæ, " le Corail " as well as the
Encrinites. Pallas, in his ' Elenchus Zoophytorum,' 1766,
accepted the classification of Linnæus and gave the following
generic description :—" Colony arborescent, sedentary ; axis
calcareous, porous with longitudinal striations, or jointed, bearing
a fleshy cortex ; verrucæ sparsely scattered ; polyps flower-
shaped, oviparous, with a crown of tentacles, retractile."
Under this category he placed the following species :—*I. nobilis*,
I. dichotoma, I. ochracea, and *I. hippuris*. In 1786, Ellis &
Solander, in ' The Natural History of many curious and
uncommon Zoophytes,' p. 105, defined the genus in the following
terms :—" An animal growing in the form of a plant whose stem
is stony and jointed ; the joints are furrowed longitudinally and
united together in some by a spongy, in others by a horny
substance. It is covered over by a soft porous and cellular
flesh, full of little mouths from whence the polyps with their
claws come forth, through whom the eggs are produced."
They also noted the relationship between this genus and the
Gorgonids, a relationship based on the presence in both of
" the axis, support or bone of the animal " ; the only difference
being the presence of joints in that of the genus under con-
sideration, while in the latter the axis is horny throughout.
They suggest that the "articulation" of the axis is an adaptation
for swaying in the water, flexing backwards and forwards in
the currents, and so minimising the possibilities of fracture.
To these eminent naturalists we are also indebted for the first
figures of any species of this genus, Tab. 3. figs. 1–5 repre-
senting various parts of *I. hippuris*, Linn. The only other species
described by them are *I. ochracea* and *I. coccinea*. It is also to

Ellis and Solander that we are indebted for the introduction of the terms nodes and internodes; but it must be noted that these are used to describe the calcareous and horny parts respectively, whereas the converse usage is now adopted. The following is their description:—" Axis articulated, calcareous, sparsely branched; the calcareous portion is white, cylindrical and furrowed; the internodes are black, horny, constricted, and attached to the nodes." In 1791 Esper depicted the axis in three fine plates, and gave a good general description of external features. Lamarck, in 1801, placed this group between the Gorgonacea, with an axis apparently horny, and the "Corail," with an entirely calcareous skeleton. In a later work, published in 1816, he narrowed down the generic distinctions and established a new group, "les Mélitées" (Genus *Melitæa*). Following this, Lamouroux in the same year established yet another division under the name of "les Mopsés" (Genus *Mopsea*); and at the same time united the three under "l'ordre des Isidées," *i. e.*, "tous les Coralliaires dont l'axe est articulé." This innovation was not accepted by Blainville in 1834 (XVI.), but was adopted by Ehrenberg 1834 (XVII.), Lamarck 1836 (XII.), Dana 1846 (XIX.), and Milne-Edwards & Haime in subsequent works (XX., XXI., & XXII.).

The classification would thus appear as follows:—

Isidinæ with an axis which bears internodes ⎰ (*a*) horny in appearance. Branches borne on ⎰ (1) the calcareous nodes = *Isis*. (2) the horny internodes = *Mopsea*. (*b*) of a suberous appearance......... = *Melitæa*.

Lamarck's 'Hist. Nat. des Anim. sans vertèb.' 2nd ed. 1836, vol. ii. p. 473, thus defines the genus:—" Colony attached, tree-like, composed of a jointed axis surrounded by a cortex not cohering but deciduous. Axis central, erect, branched, formed of calcareous striated *nodes* and horny constricted *internodes*. The cortex bears polyps in the fresh state, but is totally or partially deciduous when taken from the water." The writer discusses the question of relationship, and from the presence of horny internodes suggests affinity with *Gorgonia* and *Antipathes*, in which, he remarks, the axis is not calcareous but entirely horny. Brief notes on the following species are also given:— *I. hippuris*, Linn., *I. elongata* (Esper), *I. dichotoma* (Linn.), *I. encrinula* (Lamk.), *I. coralloides* (Lamk.), *I. gracilis* (Lamk.), *I. erythracea* (Lamk.), and *I. melitensis* (Lamk.).

Dana, in his 'Zoophytes,' 1846 (XIX.), thus limits the genus :—
" Isinæ consisting of corneous and calcareous joints alternately ;
branches proceeding from the calcareous joints ; cortex thick,
deciduous."

In 1857 Milne-Edwards & Haime (XXII.) recapitulate the
genus in the following terms :—" Colony with axis alternately
calcareous and horny ; calcareous portions sclerobasic, varying
n length according to the specimen and having horizontally
disposed ridges straight or bent ; branches borne on the calcareous
portion." At the same time they refer briefly to two new species
established by Steenstrup, viz. *I. polyacantha* and *I. monili-
formis*, as well as to the older species *I. coralloides* (Lamk.) and
I. elongata (Esper).

It will be seen that, up to this point, no account has been
taken of the spiculation; but in the 'Proceedings of the Zoological
Society,' 1857, Gray gives the following important though in-
definite amendment :—" Bark thick, with a few interspersed
very irregular and unequal spicula." His remarks on two other
points of structure are also very relevant and cannot be
overlooked :—(1) that the bark is permanent and hard, but
is brittle and easily removed, especially if the specimens be
kept in a dry place : hence Lamarck's " caduce en totalité "
(2) sometimes the horny parts become obliterated by an exces-
sive growth of the calcareous portion, and this may account
for Lamarck establishing the genus *Cynosaire* (Mém. Mus.
Hist. Nat.).

In the same work Gray also established the genus *Isidella*,
into which he merged no fewer than four of Lamarck's species of
Isis ; and at a later date (1887) G. von Koch changed his *Isis
neapolitana* to *Isidella neapolitana*. The following is Gray's
diagnosis of *Isidella* :—" Coral branched, furcate. Axis smooth,
cylindrical ; stony joint elongate ; branches furcate, proceeding
from the corneous joint. Bark rather thick, with irregular
opake spicula ; polypiferous cells produced, subcylindrical ;
base of axis expanded, lobed and branched."

The genus under consideration has thus received its position
from the nature of its axis, with but indefinite knowledge of
cortex, polyps, and spicules ; but in 1865 Kölliker, in his 'Icones
Histiologicæ,' rendered this part of the work more precise by his
introduction of a more definite spicular basis of classification.
The following gives precisely his important addition :—" I know
only the spicules of the cœnenchyma of *I. hippuris*, which

exhibit spindles beset with spiny warts, of which the simplest are in sixes, eights, or twelves. Some are simple clubs, and probably represent those of the cortical layer. The warts on one side are smaller than those on the other. Tetraradiate forms are not uncommon. The size of the largest spicule is 0·18 mm." The only other species referred by him to this genus are *I. moniliformis* (Steenstrup), *I. gracilis (Mopsea gracilis)*, Lamouroux.

Studer in 1878 established a new species, *I. antarctica*; and G. von Koch, in 1887, referred to this genus another form under the name *I. neapolitana.*

Wright & Studer, in the 'Challenger' Report, vol. xxxi. 1889, tersely sum up the foregoing characters, and accept Kölliker's description of the spicules of *I. hippuris* as typical of the genus, placing it in the Family Isidæ, Subfamily Isidinæ. At the same time the genera *Primnoisis* and *Callisis* were added to the classification, and this necessitated the abolition of certain species formerly placed in the genus *Isis*.

Thus we see that since the genus was established by Linnæus in 1737 no fewer than nineteen species have been added by various authors, but, strange to say, only one now remains as an authentic species, viz. *I. hippuris* (Linnæus). The following table represents these species, the second column indicating their place under the present system of classification and nomenclature :—

Isis antarctica, Stud., 1878.	*Primnoisis antarctica*, W. & S., 1889.
I. aurantia, Esper, 1797.	*Melitæa aurantia*, Gray, 1857.
I. capensis, Stud., 1878.	*Primnoisis capensis*, W. & S., 1889.
I. coccinea, E. & S., 1786; Gmel.; Esper.	*Melitæa coccinea*, Gray, 1857.
I. coralloides. Lamk., 1836; M.-Edw. & H., 1857.	*Isidella* (?) *coralloides*. Gray, 1857.
I. dichotoma, Linn., 1737; Lamk., 1836.	*Mopsea dichotoma*, W. & S., 1889.
I. dichotoma, Pallas, 1760. *Mopsella dichotoma*, Gray, 1857.	*Melitodes dichotoma*, W. & S., 1889.
I. elongata, Esper, 1797; M.-Edw. & H., 1857; Lamk., 1836.	*Isidella elongata*, Gray, 1857.
I. encrinula, Lamk., 1836.	*Mopsea encrinula*, Gray, 1857.
I. erythracea, Lamk., 1836.	*Isidella elongata*, Gray, 1857.
I. flexibilis, Pourt., 1868.	*Callisis flexibilis*, W. & S., 1889.
I. gracilis, Lamk., 1836; Lamx.	*Isidella elongata*, Gray, 1857.
I. gregorii, Gray, 1868.	

hippuris, Linn., 1758 ; Pall., 1766 ;
   & S., 1786 ; M.-Edw. & H.,
   1857 ; Gray, 1857 ; Köll., 1865 ;
   W. & S., 1889.
. *melitensis*, Lamk., 1836.
I. *moniliformis*, Steenstrup ; M.-Edw.
   & H., 1857.
I. *neapolitana*, von Koch, 1887.
I. *nobilis*, Pallas, 1766 ; Lamk., 1822.
I. *ochracea*, Linn., 1758 ; Pall., 1766 ;
   Esper, 1797 ; Gmel. ; E. & S., 1786.
I. *polyacantha*, Steenstrup ; M.-Edw.
   & H., 1857.

Isis hippuris, Linn., 1758.

[1887.

Isidella neapolitana, G. von Koch,
Corallium rubrum, Lam., 1801.
Melitæa ochracea, Gray, 1857.

I. gregorii, *I. melitensis*, *I. moniliformis*, and *I. polyacantha* are almost names without descriptions, and so cannot with certainty be referred to their proper place in classification.

Isis hippuris.

1608. *Hippuris saxea*, Clusius, I. p. 124.
    Corallium album articulatum, Seba, t. iv. p. 202, pl. 110. fig. 1.
1737. *Sertularia ramosissima*, Linnæus, II. p. 480.
    Isis hippuris, Linnæus, 1758, III. p. 799 ; Pallas, 1766, VI. p. 233 ;
    Ellis & Solander, 1786, VII. p. 105, pl. 3. fig. 1 ; Esper, 1797,
    VIII. tom. i. p. 279, pl. 1, pl. 2, pl. 3 A. figs. 1–5 ; Lamouroux,
    1816, XIV. p. 475 ; Lamouroux, 1821, XV. p. 59, pl. 3. fig. 1 ;
    Lamarck, 1816, XI. tom. ii. p. 302 ; Blainville, 1834, XVI.
    p. 503, pl. 86. fig. 1 ; Lamarck, 1836, XII. p. 475 ; Steenstrup,
    XVIII. ; Cuvier, Règne Anim. tom. iii. p. 312 ; Dana, 1846,
    XIX. p. 144 ; Milne-Edwards & Haime, 1857, XXII. ; Gray,
    1857, XXIII. p. 283 ; Kölliker, 1865, XXIV. p. 140, tab. 19.
    figs. 42 & 43, tab. 16. fig. 4 ; Wright & Studer, 1889, XXXII.

In 1766 Pallas, in his 'Elenchus Zoophytorum,' gives a brief summary description couched in the following terms :—" Axis articulated, alternately branched; cortex thick and slightly porous." Twenty years later Ellis & Solander, with their usual precision and careful observation of detail, describe some specimens obtained at Sunda and Sumatra. Their somewhat lengthy description (*i. e.*, in comparison with the usual terse and contracted diagnoses of the time) is well worth quoting :—
" Jointed stony stem, which rises into many loose branches. The bone or support of the animal consists of white, cylindrical, stony, channelled joints connected together by black contracted horny intermediate ones. The flesh is whitish, plump and full of minute vessels ; the surface of it is full of the little mouths of the cells which are disposed in a quincuncial order, covering the

polyps with eight claws. In length they vary from 5 inches to 1 or 2 feet or more. In some the stony joints are longer and the black horny joints very short; in others the black horny joints are longer but always more contracted. The coral spreads its base on rocks by various turnings and windings both of its bony and fleshy part, and likewise as it rises we find it enclosing shells and other extraneous substances, that stick to it, like the Gorgonias." To Ellis & Solander we are also indebted for the only figures of this species showing the cœnenchyma. These are reproduced by Esper and supplemented by fine figures of the skeleton.

In 1821 Lamouroux specifies it as follows:—" Branched, branches few in number; cortex thick; polyps not having protruding verrucæ; axis articulated, nodes calcareous, with irregular longitudinal striations, internodes horny."

The new edition of Lamarck, in 1836, practically adds nothing to the description, but emphasises Ellis & Solander's points thus:—" Cortex thick, non-prominent verrucæ, polyps with eight tentacles (claws)." Ten years later Dana referred to this species several specimens from the East Indies, but does not in any way give more precision to this little-known group.

The next and last reference to newly-collected and authentic specimens is made by Milne-Edwards & Haime, who, in 1857, thus defined the species from specimens collected at Amboina:—" Colony large and branched, branches elongated, almost straight; calcareous nodes subcylindrical, elongated, two or three times longer than broad, with sinuous striations; internodes very short and horny." In 1865, however, Kölliker, in revising the Alcyonaria in his ' Icones Histiologicæ,' makes reference to the spicules of this species. He says they consist of (1) spindles beset with spiny warts, of which there may be six, eight, or twelve on each; (2) simple clubs, probably representing the cortical layer, with the warts on one side longer than those on the other. The size of the largest spicule is 0·18 millim. In the ' Challenger' Report, vol. xxxi., Wright & Studer, having found no specimens of this species in the collection made during that voyage, to make their classification complete give the following diagnosis, which is the last systematic reference to the genus:—" Colonies branched, with thick cœnenchyma, within which the polyps can be wholly withdrawn. The spicules are radiately stellate and covered with rough warts, of which there may be six, eight, or twelve on each. Some simple club-like forms also occur."

From the foregoing considerations it is at once evident that this genus is not only so far imperfectly described but also insufficiently known to warrant its rank in a thoroughgoing modern classification. It is hoped that the following observations may give more precision and definiteness to a species, the sole representative of a distinct family.

In the Littoral collection made by the Royal Indian Survey Ship 'Investigator' in the Indian Ocean are a number of specimens which I have no hesitation in referring to this widely distributed species. Almost all are of a light brown colour, which in the dry condition appears as buff or ochreous-yellow. In some of the specimens which have been damaged and are apparently decayed the cœnenchyma is almost white.

As the colonies under examination present certain differences *inter se*, and at the same time do not altogether conform to the figures given by Ellis & Solander and reproduced by Lamouroux, it will be useful to make a few general notes on the more typical specimens, before discussing in detail the features of more diagnostic importance. The following measurements were taken of the height, breadth, and thickness, in centimetres :—

I. $9.5 \times 8 \times 3.5$.   II. $9 \times 6 \times 4$.   III. $7 \times 6 \times 3$.   IV. $10.5 \times 4 \times 2$.
V. $6.5 \times 7 \times 4$.   VI. $5.5 \times 4 \times 4$.   VII. $6 \times 4 \times 3$.   VIII. $6 \times 4 \times 3$.

In the largest and most complete specimen (Pl. **43.** fig. 1) the branching is somewhat antler-like and is mostly confined to three planes, so that the great majority of the branches are directed towards one surface. The main stem is 8 millims. in diameter, and about 3 centims. from the base two large branches arise at slightly different levels. The sinuous nature of the branches is a marked feature in this colony, the branches themselves being separated by distances of about 5 millims. The secondaries and tertiaries are short, thick and cylindrical for the greater part of their length, but have characteristic steep conical terminations. One of the larger branches is devoid of cœnenchyma, and shows clearly the internodal origin of the subsidiary branches.

A second specimen, which is incomplete, consists of part of a main stem 6 centims. in length, from which several branches arise in all directions. Of these, however, only one, which is 9 centims. in length, bears the terminal twigs intact. The branches spring from the main stem at varying angles, about 45° being the most frequent. The large complete branch curves inwards toward the main stem and gives origin to several smaller

branches, some of which remain simple while others bear curved twigs.

The third of the specimens whose measurements are given (Pl. **43**. fig. 2) may be regarded as the most typical, although it is evidently only the terminal portion of a large colony. It is very robust and bushy in appearance and maintains a marked upward growth. The main branch is 8 millims. in diameter, and gives origin to several almost equal branches of about 5 millims. in diameter. From these, secondary twigs diverge in all directions, but all have their growing tips pointing upward. The average diameter of these is about 3·5 millims. at their origin, but many terminate in club-shaped processes which increase this measurement to about 6 millims. Owing to excessive growth in the cœnenchyma, the angle between a twig and its support becomes almost obliterated ; so that a branch presents a somewhat palmate appearance, with short blunt digitiform processes—the growing tips of the twigs (Pl. **43**. fig. 2).

The next largest specimen is much damaged and may be the basal portion of a very large colony. The main stem, which is incomplete, is 7 centims. long and has a diameter of 9 millims. at the base, diminishing to 4 millims. at the broken tip. The branches which arise from it do not seem proportionate to the main stem, but there is evidence of the broken remains of larger branches now quite overgrown by the general cœnenchyma. The sinuous and cylindrical character of the branches is a marked feature.

The other four colonies whose measurements are given agree, on the whole, most closely with the third specimen.

Thus we see that the general tendency in this species is towards an upward bushy growth (Pl. **43**. fig. 2), but in the largest and most complete specimen (Pl. **43**. fig. 1) the twigs were directed mainly towards one aspect.

Another remarkable feature here presented is the fact that *there is no hint of attachment.* The basal portion is very thick and has evidently been broken from its support, but it is now completely overgrown by the cœnenchyma. This secondary growth is to be seen in the case of another branch in this specimen, and is not of infrequent occurrence in several of the others. May not this circumstance, to a great extent, explain the unilateral direction of the growing points of the branches in this specimen, as contrasted with the typical form in the others ? Having become detached from its support, and with a

tendency to lie horizontally, the colony would produce branches towards the upwardly directed surface. It seems to me that this consideration is worthy of attention in reference to other plastic colonies whose contour is subject to great modification through position, the agency of currents, and the like. It leads one to recognize that the general shape of a colony affords but a slender basis on which to raise a superstructure of classification.

In this specimen also the development of club-shaped ends on the twigs is hardly noticeable; and as this feature is most predominant in the forms with developing eggs, it may be a nutritive phenomenon or a natural safeguard against premature rupture by the ever-increasing abnormally large embryos.

The axis (fig. 1) consists of white calcareous internodes and brown horny nodes. The internodes are symmetrically sculptured, ridges and furrows alternating around the whole circumference. The ridges appear smooth to the naked eye, but when slightly magnified present a beautifully serrated edge. They vary in number in the different parts of the colony, being comparatively fewer in the younger portions. Twelve, thirteen, and fourteen are common on the larger branches. In the older parts of the colony the internodes are almost cylindrical, but on the primary and secondary branches they are slightly narrower at the middle, while in the twigs they are torpedo-shaped. The nodes resemble fish-vertebræ in form. They are short and markedly constricted, and have a silky lustre. At the ends they are slightly ridged, conforming to the contour of the internodes; but this gradually diminishes, so that at the centre they are perfectly smooth. They contain no calcareous matter, except near the base, where a central limy rod connects them with the internodes. In mass they appear dark brown, but in section the colour is golden yellow.

The nodes and internodes vary in length throughout the colonies, so that no general size can be stated as typical. The following measurements of a node and its adjacent internode were taken at different parts:—

(a) Main stem:

    Internode 4·5 millims. in length and 7 millims. in diameter.
    Node   3   ,,   ,,   6   ,,   ,,

(b) Branch:

    Internode 6 millims. in length and 3 millims. in diameter.
    Node   ,,   ,,   ,,   1·5   ,,   ,,

The branches arise from the calcareous internodes, generally one from each; but as many as three sometimes occur on one internode. In most cases there is a considerable calcareous portion before the first node; but this is often so reduced that the branches seem to arise with a horny part. In other places, owing to the origin being close to the node, the branch seems to arise from it.

Cross and longitudinal sections of a calcareous part, 1 centim. in diameter, were ground to show the internal structure. There is a distinct radiate appearance from centre to periphery. About 1·2 millims. from the centre there is an undulating line which corresponds to the grooves on the outside, but in this case they are fewer in number. Towards the circumference, and at a distance similar to the first, there is another almost identical line with a greater number of undulations, but still fewer than those on the periphery. These wavy lines doubtless correspond to what were previously the external surfaces of the axis. The central portion is quite homogeneous in character and is apparently amorphous; but in the younger part it is evidently composite, the small particles giving different extinctions. It cannot be argued from this, however, that the axis is sclerogorgic, because the boundary-lines of the different parts may be the organic remains of the dead calicoblasts. At the same time, it is important to note that in similar sections of *Melitodes* little or no difference could be found. This subject is worthy of further study, seeing that it is used as a basis of classification. When the internodes were decalcified, there was a considerable residue of organic matter.

The cœnenchyma is very thick (Pl. **43**. fig. 3), in some parts 2·5 millims. It is supported by small, densely-packed spicules of various shapes, which make it very brittle; and hence the markedly deciduous character, so often referred to. On the surface there is a layer of spicules arranged so that all their warty ends project outwards, and so form a specially hard protective layer. Owing to the enormous preponderance of spicules, it was almost impossible to cut sections. Decalcification resulted in a complete collapse of the cœnenchyma.

The nutritive system consists of (1) a longitudinally arranged set of canals, one corresponding to each groove on the axis; (2) a branching system throughout the cœnenchyma connecting these with the individual polyps. These canals have soft flaccid

walls, are circular in section, and have a diameter in some cases of about 1 millim.

The polyps (Pl. **43**. fig. 4) are scattered over the whole cœnenchyma at intervals of 0·5 to 0·1 millim. There are no verrucæ; so that when the anthocodiæ are withdrawn the surface presents a dotted appearance. Round each of the openings the spicules are grouped in eight bundles, and so form a stellate figure. The expanded polyp has a length of 1·25 millim.

The tentacles are 0·5 millim. in length, with a diameter of 0·5 millim. at their base. They are flat and lanceolate, and bear a single row of short, thick, cylindrical pinnules. They are first infolded so as to form a somewhat elongated cone, and then the whole is withdrawn within the level of the cœnenchyma. The polyp-cavities (Pl. **43**. fig. 3) are vase-shaped, and have a depth of 1·25 millim., with a maximum diameter of similar dimensions.
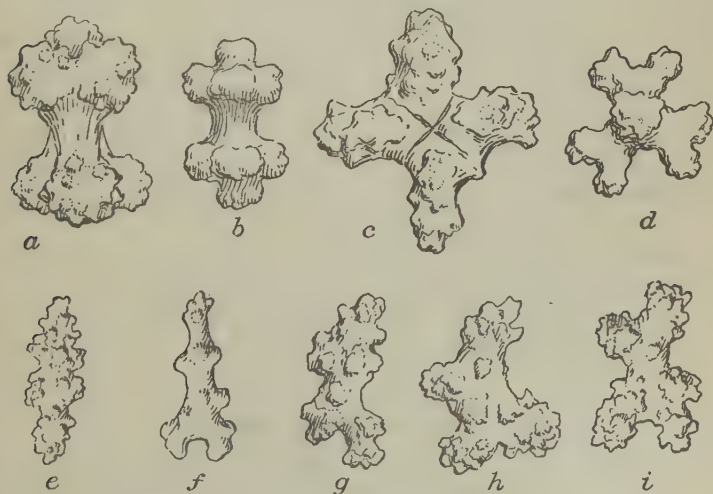
Spicules *a–i*: different types from the cœnenchyma.

It is interesting to note that we have here another example of viviparity among Alcyonaria. As Prof. Hickson notes ('Marine Investigations in South Africa,' vol. i. (1902) p. 84), the occurrence of embryos has been recorded in *Corallium rubrum* (Lacaze-Duthiers), some species of *Clavularia*, *Sympodium* (*Alcyonium*) *coralloides* (Marion and Kowalewsky) and in three

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species of *Nephthya* (Koren and Danielssen). To these Hickson added *Gorgonia capensis*. As embryos have also been noted by Thomson and Henderson in *Chrysogorgia flexilis*, *Ceratoisis gracilis*, *Distichoptilum gracile*, *Pennatula indica*, *Umbellula elongata*, *Funiculina gracilis*, *Clavularia pregnans*, and *C. parvula*, it is evident that viviparity occurs in very diverse types of Alcyonarians.

In some of the specimens under consideration embryos of enormous size are present. These are situated either singly or in pairs, though in some cases three are to be found. They have a diameter of about 1 millim., and are apparently in an advanced stage of development. They are of the same colour as the general cœnenchyma and present a glistening appearance.

The spicules are very diverse in character. The following are some of the more prominent types, with measurements of length and breadth in millimetres :—

(*a*) Cœnenchyma.
    (1) Rods with at each end a whorl of three large papillose warts : 0.2×0.1, 0.2×0.15.
    (2) Tri- and quadri-radiate forms : 0.1×0.1, 0.125×0.125.
    (3) Stellate forms with warty knobs : 0.1×0.1, 0.075×0.075.
    (4) Short rods with large warty knobs irregularly arranged : 0.2×0.125, 0.15×0.1.
    (5) Irregular and intermediate forms : 0.2×0.1, 0.07×0.07.
(*b*) Anthocodiæ. Similar forms, but slightly smaller.
(*c*) Tentacles. Stout rough clubs with short handles, warty at the end : 0.055×0.045, and 0.2 at the narrow smooth part.

Locality. Andaman Sea, 20 fathoms ; also surf-line.

Previously recorded from :—Pacific Ocean (*Wright & Studer*) ; Indian Ocean (*Ellis, Pallas*). Mediterranean Sea (*Pallas*). America (*Pallas*). North Sea (*Linnæus*). Iceland (*Olafsen & Polvesen, Lamouroux*). Antilles and United States (*Lamouroux*). Straits of Sunda and Southern Coast of Sumatra (*Ellis*). East Indies (*Dana*). Amboina (*Milne-Edwards & Haime*).

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EXPLANATION OF PLATE 43.

Fig. 1. Colony (without attachment) (nat. size), showing the unilateral method of branching ; also a part of the axis devoid of cœnenchyma, showing the ridges and furrows ; also the internodal origin of the branches.

2. Typical colony (nat. size), showing the palmate terminations of the twigs.

3. Tip of a branch (× 10) with one half cut away, showing (i) the excessive thickness of the cœnenchyma ; (ii) the longitudinal nutritive canals ; (iii) the retracted polyps sunk in cavities in the cœnenchyma ; (iv) the enormous embryos *in situ* ; (v) the thick muscular bands.

4. Part of the surface of the cœnenchyma enlarged (× 14), to show the polyps in different stages of retraction, with the small mound-like elevations.

Notes on some Species of *Nereis* in the District of the Thames Estuary. By H. C. SORBY, LL.D., F.R.S., F.L.S.

[Read 1st March, 1906.]

FOR more than 20 years I spent four or five months each summer (May to September) on board my yacht ' Glimpse' in various parts of Kent, Essex, and Suffolk, devoting myself much to the study of the marine animals. During this time I was able to observe a number of interesting remarkable facts connected with the *Heteronereis* form of two species of *Nereis*, which occur rarely.

Except in a few rare cases, when properly mounted in balsam, the natural colour is to a great extent preserved, and it is quite easy to see the form and colour of the jaws, even when completely retracted, and the form and colour of the prickles about the head, and of the eyes, as seen by transmitted light, and the ova, when present, which is not the case when specimens are preserved in alcohol or formalin.

The species found by me in the district of the Thames estuary are as follows :—

1. *Nereis diversicolor*, Müller.—Often very common in the mud of the estuaries left dry at low water, but rare in some of them.

2. *N. Dumerilii*, Audouin & Milne - Edwards.—Living in tubes formed amongst the marine plants. It must be numerous in some localities, but often lost when the plants are dredged up.

3. *N. longissima*, Johnston.—Very rarely found in the mud, but must be fairly common in some places.

1.

2.

3.

4.

ISIS HIPPURIS *Linn.*
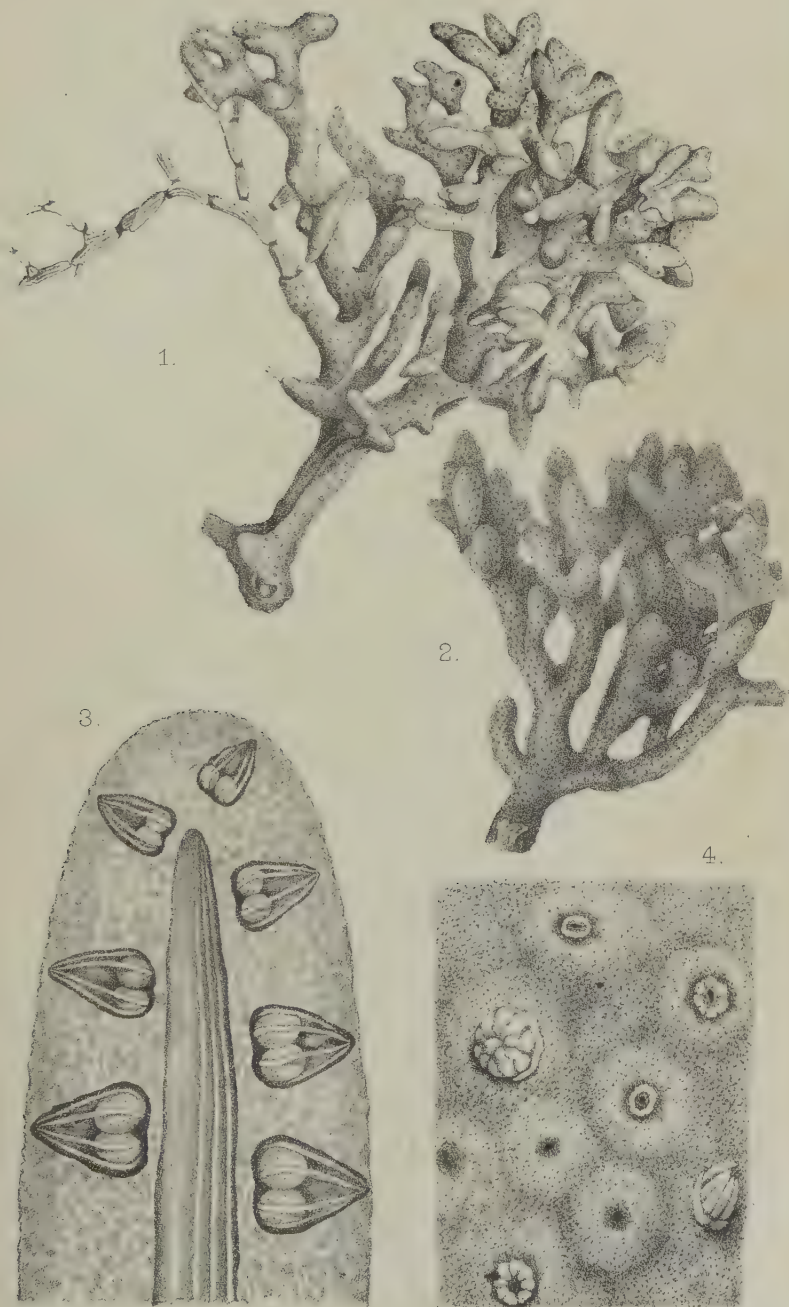
4. *N. pelagica*, Linn.—At one time was common off Harwich amongst the sandy tubes built by *Sabellaria spinulosa*, Lamarck.

5. *N. cultrifera*, Grube.—Common in the mud at low water in particular localities, especially at the mouth of the Colne and off Harwich.

When mounted in balsam these species can be at once distintinguished from one another by the following characters :—

1. *N. diversicolor.*—Numerous small black prickles about the head.

2. *N. Dumerilii.*—Unusually long tentacular cirri. Eyes black and very large for the size of the animal, those of each pair very close or even partially coalesced.   Prickles almost or quite invisible.

3. *N. longissima.*—Prickles very obscure or invisible.   Eyes pale brown by transmitted light.   Tentacular cirri short. Jaws dark-coloured, with rounded teeth.

4. *N. pelagica.*—Numerous prickles of varying size and somewhat rounded shape, of pale brown colour by transmitted light.

5. *N. cultrifera.*—Unusually large black angular prickles. Many small blood-vessels perpendicular to the length of the parapodia.

One great advantage of these characters is, that they apply equally well to the *Nereis* and *Heteronereis* state, and can be seen at once without injury to the specimen.

I have found only one specimen of *N. longissima* in the *Nereis* condition, obtained in the mud of the Orwell at Pin Mill, which is 7 inches long and over $\frac{1}{4}$ inch thick.   When put into diluted formalin, it broke itself into two, which I never knew happen in the case of any other species.   I have seen and caught it in the *Heteronereis* condition on only two occasions.   The first was off Sheerness, in the evening of May 11th, 1882.   I saw round the yacht large numbers of what I thought were small red fish swimming near the surface at the rate of several miles an hour ; and, on catching some, was astonished to find they were worms about $4\frac{1}{2}$ inches long.   On putting some into my large aquarium, a small *Pandalus* seized one two or three times as large as itself and carried it down to the bottom.   The second occasion was late in

the evening of Sept. 9th, 1889, at Queenborough, where numbers
were swimming about us. Unfortunately only four specimens
were preserved, since I expected to collect more the next day;
but though I carefully looked for them in that and subsequent
years, I never saw another. I also never found one in the mud,
and do not know exactly where they or the *Nereis* form live
permanently in the district of Queenborough. Some of the
specimens are small, being only two inches long, and one differs
so much from the rest that at one time I looked upon it as a
different species.

The case of *N. Dumerilii* is still more remarkable. I have lived
several weeks, nearly every summer, for many years on the Stour
and Orwell, and though carefully looking out for anything
swimming near the surface, I do not remember seeing a single
specimen of the *Heteronereis* except on July 16th, 1898. When
I went on deck at 5 A.M. in Harwich Harbour, great numbers
were swimming around as far as could be seen, and I was led to
conclude that they extended over such a wide area, that possibly
the total number was something like a million. None could be
seen two hours later. They were of small size, the largest caught
being not quite an inch and a half long. The remarkable fact is,
that such numbers should come to the surface at nearly the same
time, over a considerable area, and swim about for a few hours
and suddenly disappear without any apparent cause. As far as
I and Professor Denny have been able to make out, all were
males, and I did not see any ova voided from the considerable
number of specimens collected and kept alive in sea-water for
several hours, when all died, though caught and treated with
great care. A number of specimens kept for a considerable time
in a large aquarium passed into the *Heteronereis* state, but were all
dead when first observed, and I have no evidence that they lived
long in that state. I have, however, kept alive for weeks or
months a number of specimens not in the *Heteronereis* condition
and observed their habits. Put into a glass of sea-water they
very soon secreted a semi-transparent tube, which they sometimes
deserted and formed another. I kept some with a moderately
large piece of *Ulva latissima*. In this they secreted a tube open
at both ends, from which they came out when disturbed and
went back again. They had nothing to feed upon but the *Ulva*,
which they evidently eat, and their excrements were manifestly
pieces of undigested *Ulva*. One, however, grew up to be a fine
specimen full of eggs; and one day, when disturbed, it wriggled

about and voided eggs, which I mounted on a lantern-slide, and carefully estimated their numbers at about 20,000. It had not passed into the *Heteronereis* condition; but I have mounted specimens of smaller size obtained elsewhere which are in that state and yet are full of eggs. The female, 3 inches long, which laid the eggs was mounted in balsam, and in general appearance differs remarkably from those full of partially developed eggs.

Another peculiarity of *N. Dumerilii* is that the large specimens from the Orwell, when mounted in balsam, turn from a pale red to a dark brown, even when the blood-vessels are well preserved, so that it is not due to decomposition, but as though some unusual pale substance changed gradually into a dark brown one. In no other species of Chætopod have I seen such a change.

The only other Chætopod that I have seen swimming in considerable numbers near the surface is *Siphonostoma* (*Flabelligera*) *affine* (M. Sars). In several years, before and after 1890, this was so abundant in the Orwell, that many objects dredged up were covered by scores of individuals. I have never seen any elsewhere or in the Orwell since. Many left the bottom and came near the surface, where they wriggled about and were carried along by the tidal current, and this continued day after day. Many were full of eggs, which they voided when kept alive, and my impression was that when swimming they were dispersing their ova. This case is interesting because it differs so completely from what I have observed in the case of *Heteronereis*, and so easy to understand.

N. cultrifera.—Baron de Saint-Joseph, in his work on the *Polychæta* of the coast of France, describes fully the characters of the male and female *Heteronereis* of this species, but does not allude to the *Nereis* form so common in South Britain. This is remarkable because, though during the whole of the summer months I have collected large numbers on the coast of Essex, I never saw one in the *Heteronereis* condition. I may also say that none of my numerous mounted specimens contain ova. It is of course possible that their development and the change to *Heteronereis* may occur at a time of the year when I was not on the yacht, or occurs very rarely. Dr. Allen informs me that it does occur at Plymouth, but in much smaller numbers than the *Nereis*.

N. pelagica.—I have never obtained a single specimen of the *Heteronereis*, which occurs in some localities abundantly between tide-marks.

In addition to the three cases already mentioned, I saw a number of *Heteronereis*, probably of *N. Dumerilii*, swimming at the surface in the Colne at high water on the evening of May 23rd, 1885, and also a large species in the Orwell, probably *N. longissima*, at high water when fine and hot on May 24th, 1889 ; but no specimens were caught so as to make me sure of the species.

On the whole, then, during several months each year in summer for about twenty years, I saw only five cases in which large numbers of *Heteronereis*, certainly of two species, were seen swimming at the surface, or about one case for each species in eight years. Of course I was not constantly on the look out, and cannot say what happened during the night or when the sea was rough, and I was not always in places where it was likely to occur. Taking all these things into consideration, it is quite possible that this simultaneous surface-swimming in large numbers may occur every year. It evidently may take place in the early morning, at midday, or in the evening, and in the early, the middle, or the late part of the summer months. When it does occur, it is such a striking spectacle that it seems worthy of being recorded. Unfortunately I have never been able to observe any facts which afforded a satisfactory explanation of the occurrence. My observations agree well with what has been seen at Plymouth. Dr. Allen informs me that in April 1885 numbers of the *Heteronereis* of *Nereis longissima* were seen by Dr. Jonathan Herder, but nothing of the sort in later years. The *Nereis* form is found in the mud at Salcombe, of about the same size as in the Orwell.

Nereis diversicolor occurs more or less abundantly in all the estuaries of Essex, Suffolk, and Kent. In preparing specimens for permanent mounting, I have been much struck with the remarkable difference in behaviour of those obtained in different localities. In St. Osyth Creek they abound in the mud left dry when the tide is down, and when kept in sea-water to which a few crystals of menthol were added the animals were soon stupified, and after a while did not revive when restored to water free from menthol, but died. In the mud of the Crouch near Burnham this same species is so rare that few can be obtained in the course of several hours. On keeping these with menthol, it seemed to have little or no effect. Chloral hydrate also failed to kill them, and to do this I had to use such a very poisonous substance as

cyanide of potassium. The conclusion I formed was that for some reason or other, perhaps the greater salinity of the water, the conditions at Burnham were so adverse as to have developed a specially hardy race, which could withstand what easily killed those living under more favourable conditions. Nor is this all. When 16 years ago I first began to prepare and mount marine animals in balsam as lantern-slides, and took very little care, I mounted a specimen of *N. diversicolor* from the Queenborough district which shows no trace of decomposition anywhere, and the minute blood-vessels of the parapodia are most unusually well preserved, filled with red blood. I have since preserved or tried to preserve many specimens from the Orwell and the Colne estuary, and, even when using much care, I found that in drying it was very difficult to prevent decomposition setting in from one cause or another, and even in my most successful preparations the blood-vessels are well preserved only here and there. It thus seems that, even when dead, specimens from different localities may differ much in the power of resisting decomposition; animals of the same species thus varying in physiological and chemical characters. I may also say that the relative amount of hæmoglobin differs enormously, some being deep red and others quite pale.

On the Membranous Labyrinths of *Echinorhinus*, *Cestracion*, and *Rhina*. By CHARLES STEWART, LL.D., F.R.S., F.L.S.

[Read 1st March, 1906.]

(PLATE 44.)

ECHINORHINUS SPINOSUS. Fam. Spinacidæ. (Pl. 44. fig. 1.)

THE fish upon which this dissection was made was 227 cm. (7 ft. 6 in.) in length. The utricle showed the usual complete separation into anterior and posterior portions, between which lay the ductus endolymphaticus passing upwards directly to a point immediately beneath the skin, where it passed backwards and enlarged into a pigmented, somewhat rugose distensible chamber, 15 mm. in length and 4 mm. in breadth. From the posterior superior angle of this a minute continuation passed upwards and slightly backwards through the skin to the apertura externa. The anterior utricle and the recessus com-

municated by a common fissure-like opening with the sacculus. This fissure was 15 mm. in length, commencing in a point posteriorly and gradually widening to 3 mm. in front. It probably represented the canalis utriculi anterior, ductus utriculi, and canalis recessu-saccularis found in certain other Sharks, but, owing to its character, I shall speak of it as the fissura utriculo-saccularis.

The posterior utricle presented the usual characters and communicated by a round hole, about 2 mm. in diameter, with the saccule in front.

The saccule and lagena were both of large size and with the external face directed outwards and forwards.

The nerve-supply of the ampullæ was of the usual amount, that of the recessus moderate in quantity, the sacculus and lagena being very slightly supplied. The long nerve from which branches are given off to the saccule and lagena ran first of all upwards and then dipped downwards to supply the ampulla of the posterior canal, lying in the latter part of its course on the external surface of the utriculus posterior. Immediately before passing behind this structure it gave off the ramulus neglectus.

The sacculus and lagena were filled with a perfectly colourless and transparent mass of mucin of a firm jelly-like consistence, in which the otoconia (moderate in amount) were imbedded.

Immediately behind the small opening in the cartilaginous cranium, through which the ductus endolymphaticus passed, was an oval deficiency in the skull closed by tough fibrous membrane; it led directly into the large space in which the dorsal end of the posterior utricle and commencement of the posterior canal were lodged. It measured 17 mm. × 11 mm., its long axis being parallel with the posterior canal.

A similar opening has often been described in other Elasmobranchs, and is referred to in a paper by the late Prof. G. B. Howes in the Journal of Anat. & Physiol. vol. xvii. 1883, p. 188.

CESTRACION PHILIPPI. Fam. Cestracionidæ. (Pl. 44. fig. 2.)

The specimen from which this labyrinth was obtained measured about 100 cm. (3 ft. 4 in.) in length.

In proportion to this size the labyrinth is small and the otoconia, if present, scanty. The chief peculiarity of the labyrinth lay in the ductus endolymphaticus. This passed through a long canal

in the cartilage, 4 mm. in breadth, to whose anterior wall it was firmly attached by the perichondrium. After passing through the skull, it made the usual bend forwards for about 5 mm. Here I believe it ended abruptly, as, though looked for carefully, the duct was not traced further nor was any external aperture found. The recessus only communicated directly with the utricle above.

The anterior utricle communicated with the saccule by a small opening (canalis utriculo-saccularis anterior). The posterior utricle had a similar small opening into the saccule (c. utric.-sacc. posterior).

The nerves to the ampullæ of the anterior and external canals were long, and those to all the ampullæ large. Nerves supplying the recessus, sacculus, and lagena were not found, and were probably of minute size.

The outer face of the saccule and lagena was directed outwards and forwards at an angle of 45° to the mesial plane.

RHINA SQUATINA.   Fam. Rhinidæ.

Although the membranous labyrinth of this somewhat Raylike Shark has been figured and described by Retzius, yet I can nowhere find any account of a feature which is most remarkable and, so far as I am aware, unique in the Vertebrata—namely, a complete absence of otoconia, its place being taken by sandgrains introduced from without through the comparatively large external opening of the ductus endolymphaticus. The sand is often partly cemented into a thin plate that occupies the side of the saccular cavity next the macula, but elsewhere lies loose. This remarkable feature has been always found in the five or six specimens hitherto examined by me; but as it might be thought that otoconia had been got rid of through the same passage, I thought it well to examine a mature young before birth, which measured 190 mm. in length. The head was bisected, and all the tissues removed that surrounded the periotic capsule. This capsule with its contents was then divided, and the two halves of the saccule removed and examined under the microscope : no otoconia were found. As it might be thought that they were not present in other unborn Sharks, the unborn young of *Acanthias vulgaris* of similar length was examined; its saccule contained abundance of large crystalline otoconial particles.

Although this replacement by foreign particles is probably peculiar to the genus *Rhina*, a mixture of otoconia and sand has been found by my friend Mr. R. H. Burne in specimens of *Acanthias vulgaris* about 2 feet in length, but in *Scyllium canicula* minute otoconia only were present. It should be noted in this regard that both *Acanthias* and *Rhina* are figured as having a similar ductus endolymphaticus of rather large size, that passes through the skin without diminishing and terminates in a large external aperture. In *Rhina* the apertura externa lies at the anterior border of a spineless, paler, and somewhat sunken patch of skin that in adult fish measured 5 mm. in diameter, those of opposite sides being 11 mm. apart. A saccus endolymphaticus (13 mm. in length) is well-defined from the rest of the duct and lies parallel to the skin. A firm round fibrous band arises from the skin shortly behind the apertura externa and is attached to the under surface of the saccus throughout its entire length, blending again with the skin immediately in front of it. It is common in Sharks for the cutaneous portion of the duct to be reduced to a tube of great fineness, with only a minute external opening.

Of course it is well known that in most Decapod Crustacea sand is introduced into the auditory sac after each moult. Indeed, I have found the shells of Globigerinæ in the auditory sac of the Zoœa stage of a foreign Crab.

EXPLANATION OF PLATE 44.

Fig. 1. Right membranous labyrinth of *Echinorhinus spinosus*. Nat. size.
2. Right membranous labyrinth of *Cestracion philippi*. × 2.

a. Ampullæ.

a.d.e.e. Apertura ductus endolymphatici externa.

    c.a. Canalis anterior.

    c.p. Canalis posterior.

    c.e. Canalis externus.

    d.e. Ductus endolymphaticus.

d.u.s.p. Ductus utriculo-saccularis posterior.

f.u.s. Fissura utriculo-saccularis.

    l. Lagena cochleæ.

    r.n. Ramulus neglectus.

    r.u. Recessus utriculi.

    s. Sacculus.

    s.e. Saccus endolymphaticus.

    u.a. Utriculus anterior.

    u.p. Utriculus posterior.

Stewart.

Linn. Soc. Journ., Zool. Vol. XXIX. Pl. 44.

MEMBRANOUS LABYRINTHS OF ECHINORHINUS AND CESTRACION.

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END OF THE TWENTY-NINTH VOLUME.